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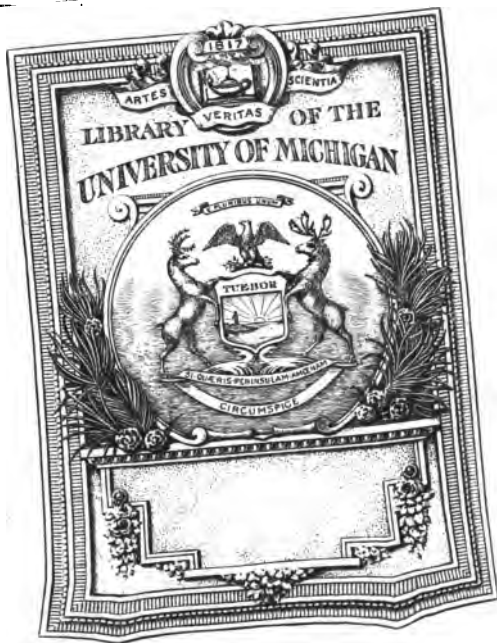
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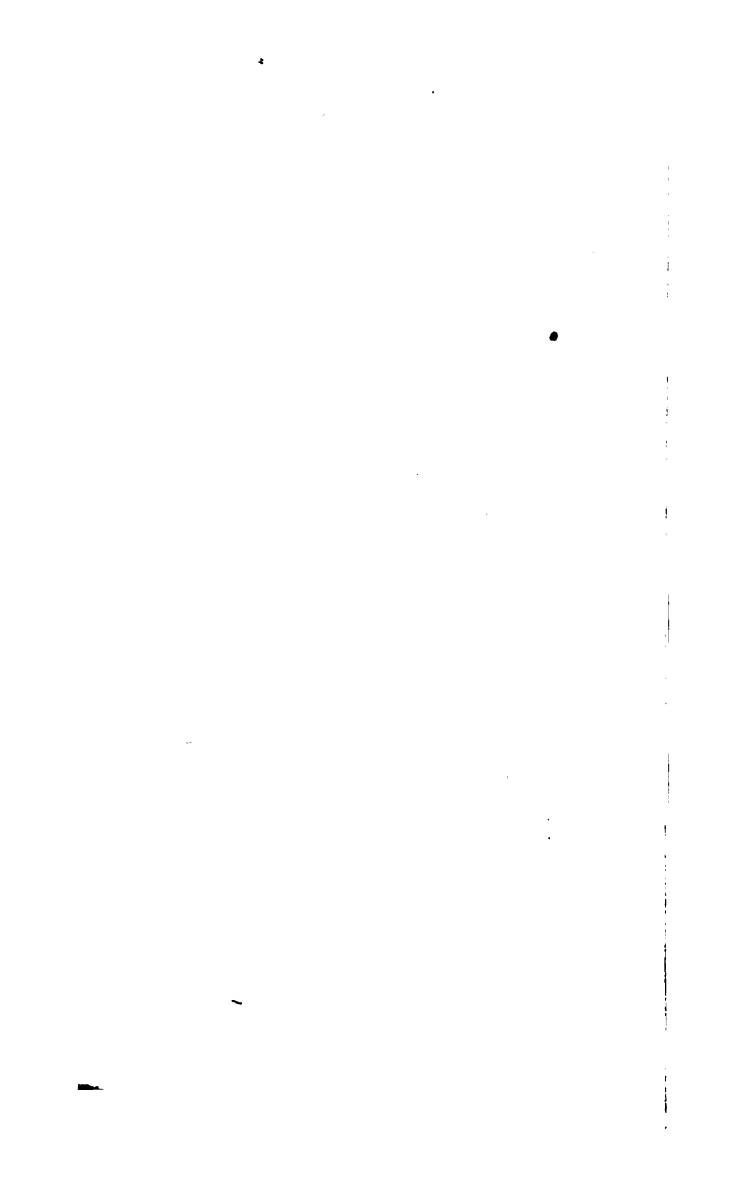
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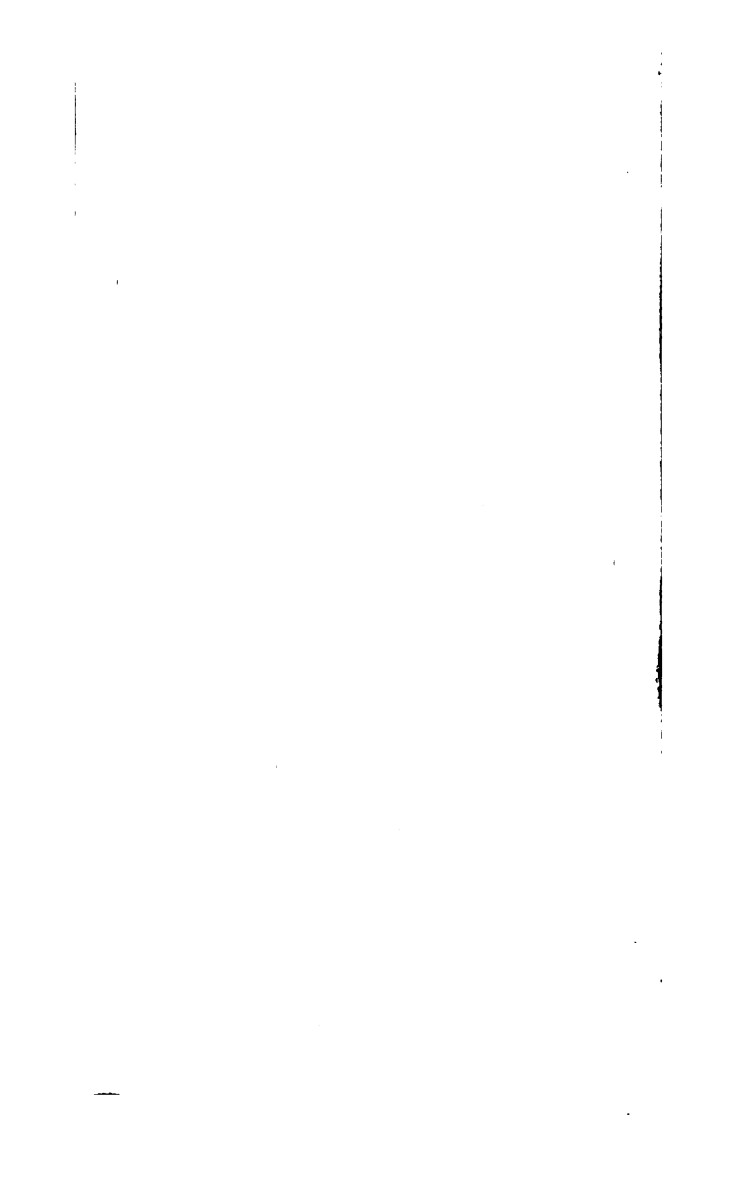
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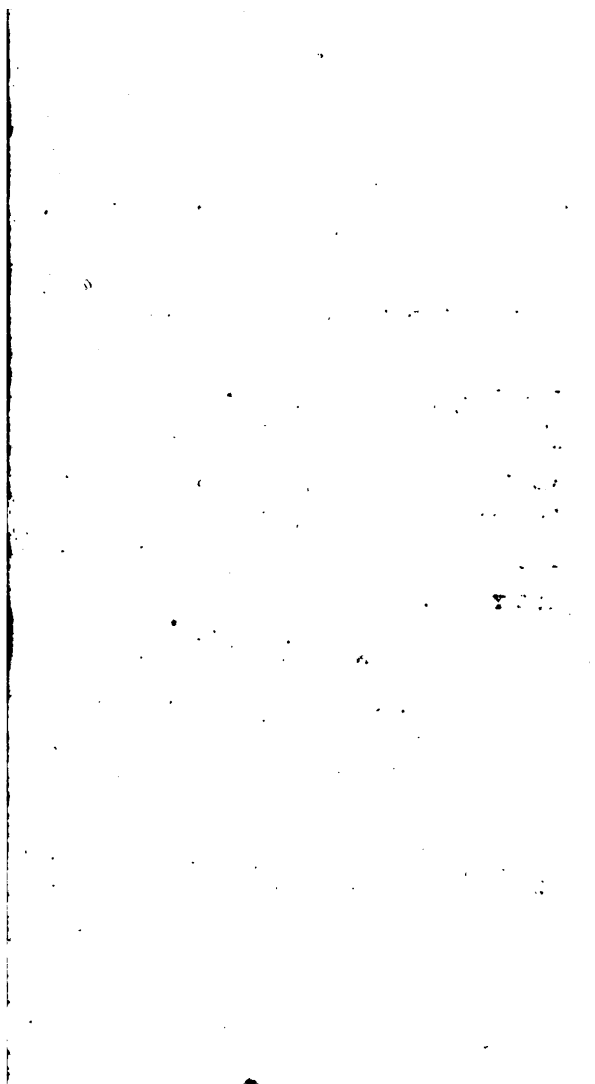
















**I** Am of Opinion, that Mr. SAMUEL  
CUNN, in his Treatise of *Decimal  
Fractions*, has very much improved the  
Doctrine thereof, and added several  
very Useful Rules; which, as I take  
it, are wholly New, and were want-  
ing to compleat that Part of ARITH-  
METICK.

Witness my Hand,  
**EDMUND HALLEY.**





A  
NEW and COMPLEAT  
**TREATISE**  
OF THE  
*Doctrine of Fractions,*  
VULGAR and DECIMAL;

Containing not only all that hath hitherto been publish'd on this SUBJECT; but also many other compendious Usages and Applications of them, never before extant. Together with a Compleat Management of CIRCULATING NUMBERS, which is entirely New, and absolutely necessary to the right using of FRACTIONS.

To which is added, an  
**Epitome of DUODECIMALS,**  
AND AN  
Idea of MEASURING.

The whole is adapted to the meanest Capacity. and very useful to BOOK-KEEPERS, GAUGERS, SURVEYORS, and to all Persons whose Business requires Skill in ARITHMETICK.

---

By *SAMUEL CUNN* Teacher of MATHEMATICKS in *Litchfield-Street* near *Newport-Market*.

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*J. Matthews*, in *Little-Britain*. MDCCXIV.

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# SECRET

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1. The first step is to identify the problem or question that needs to be addressed. This involves understanding the context and the specific requirements of the task.



# THE PREFACE.



**S**INCE the absolute Necessity of knowing Fractions, and the extreme Usefulness of them in Practice is so well known, I shall be silent herein ; and only shew in what manner I have laid down the Doctrine of them, and wherein I differ from others in the practical Management.

In the first Seven Chapters, I have handled general, or vulgar Fractions, and in the following Chapters particular, as Decimal and Duodecimal Fractions.

In order to the ready Management of vulgar Fractions, I have first laid down the Methods and Rules commonly given, and afterwards added many others, illustrated by Examples, which will greatly shorten the Work, and always give the Result in its least Terms; which is an Advantage very well worth Pursuit.

And tho' the 3d, 4th, 5th, 6th, and 7th Sections of the 1st Chapter may seem foreign to the Business of this Treatise, whoever considers them thoroughly, will find them of Use, in the ready Management of vulgar Fractions.

In the 8th, 9th, 10th, 11th, 12th, 13th, 14th and 15th Chapters, after the handling of compleat Decimals, I have shewn how to use without Loss, such as do Circulate; and also how far we may trust to Results arising from Approximates.

If Decimals are at any time used without the like Management, many gross Errors must arise, as will be manifest to every one that considers Conclusions from Approximates.

For he that only knows how to express Money, Weight, &c. Decimally, will find, that such Expressions much oftener circulate, than at any place terminate. And consequently,

# The Preface.

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quently, if he works such Decimals as Approximates, his Results will have so many uncertain places, especially in future Operations, which must, as well as hitherto it hath dishearten'd the Practisers of Decimals.

Tho' this Method of using Fractions is absolutely necessary, yet no Treatise hitherto extant hath sufficiently handled it; for the Reverend Dr. Wallis, in the 89th Chapter of his History of Algebra, publish'd in the Year 1689, treating of the Laws of Circulating Numbers, concludes thus, I have insisted the more particularly on this, because I don't remember I found it so consider'd by any other. And since him, Mr. Jones in his Synopsis Matheseos, repeats concisely part of what the Doctor had explained before at large. And lastly, Mr. Ward, in his Young Mathematician's Guide, contenteth himself with informing his Reader, That Numbers will circulate. But neither of these so much as hint at the Method of using them.

In the 3d Section of the 8th Chapter, I have laid down all the Laws of Circulations hitherto publish'd, and many more of my own; but have omitted their Demonstrations (which at first I design'd to annex) because they depend on Propositions in the 7th, 8th and 9th Books of Euclid; which by our modern

## vi The Preface.

modern Adapters are, for I know not what  
Reasons, called useless Curiosities; and so  
by them Scholars are look'd upon; and  
undervalued by such as are Mathematicians  
only.

But the Reverend Mr. Brown, in his  
System of Decimal Arithmetick, manages  
such intermediate Decimals as have a single  
Digit continually repeated; but in Multipli-  
cation uses only such Factors as will produce  
a single Repetend in the Product (being, as  
I suppose, unwilling so much as to mention  
compound Repetitions) and in Division  
leaves the Practitioner to work without Ex-  
cess.

These are all the Authors I have met  
with, that have so much as once written of  
Circulations. Yet in Gratitude I cannot for-  
get my Friend Mr. Robert Fyell School-  
Master in St. Giles's in the Fields, whose  
Hints and particular Methods have contri-  
buted to my Discovery of the Nature and  
Laws of Circulating Figures.

The Approximation of Proportions is from  
the 10th and 11th Chapters of Dr. Wallis's  
History of Algebra.

The Epitome of Duodecimals is all I ever  
found necessary in our Customary Measuring,  
wherein only they are used.

# The Preface.

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*The whole is laid down in so plain a manner, as to be intelligible to any Reader who knows Multiplication, Division, and Extraction of Roots in Integers, and Reduction of Money, Weights and Measures, &c.*

*To conclude, that this Treatise, as being so much more useful than any other Book of this Subject yet extant, may be kindly accepted, is the Desire of*

**SAMUEL CUNN.**



1875

1876

1877

1878

1879

1880

1881

1882





A  
TREATISE  
OF  
FRACTIONS.



CHAP. I.  
OF PRIMES and MEASURES.

SECT. I.  
DEFINITIONS.

1.



NITY is that by which every thing that is, is called One.

2. Number is a Multitude compos'd of Units.

3. A lesser Number is an aliquot Part of a greater, when the lesser exactly measures the greater ; and the greater is then called a Multiple of the lesser.

4. A lesser Number is an aliquant Part of a greater, when the lesser doth not exactly measure the greater.

So 4 is an aliquot Part of 12, and 12 a Multiple of 4, because 3 times 4 is 12; but 5 is an aliquant Part of 12, because 2 times 5 is 10, and 3 times 5 is 15, and consequently 5 doth not exactly measure 12.

5. A Prime Number is that which is measured only by an Unit.

6. A Composed Number is that which some Number measureth.

7. Numbers prime to one another, are such as have no other common Measure but an Unit.

8. Numbers composed to one another, are such as have some Number for their common Measure.

So 2, 3, 5, 7, are prime; 4, 6, 9, 10, 12, 14, 15, and all Numbers less than 10000, that are not in the following Table, are composed Numbers; and 15 and 21 are composed to one another, for 3 will measure 15 by 5, and 21 by 7; but 15 and 32 (tho' both composed Numbers) are prime to one another, for tho' 5 or 3 will measure 15, yet neither 5 nor 3 will measure 32.

9. A Perfect Number is that which is equal to all its own aliquot Parts taken together.

10. A Diminutive Number is greater than the Sum of all its aliquot Parts.

11. An Abounding Number is less than the Sum of its aliquot Parts.

So 6 is a Perfect Number, for the Sum of all its aliquot Parts 1, 2, 3, is 6; but 15 a Diminutive Number, for the Sum of all its aliquot Parts 1, 3, 5, is but 9; and 12 is an Abounding Number, for the Sum of all its aliquot Parts 1, 2, 3, 4, 6, is 16.

## Definitions.

3.

12. An Abstract Number is such as hath no Denomination annexed to it.

13. A Contract Number is such as hath a Denomination annexed to it.

So any Number, as 4, is called abstract; but Pounds annexed to the Number 4 (*viz.* 4 Pounds) makes it contract, and then can signify nothing but 4 Pounds.

14. A Whole Number is that which numbereth Wholes.

15. A Broken Number or Fraction, numbereth the Parts of an Unit.

16. A Mix'd Number is made by annexing a Fraction to a whole Number.

A Whole Number may be Abstract or Contract, but a Fraction may be wholly Contract, or partly Abstract, and partly Contract; for 2 thirds considered as a Fraction, is abstract, since it is not expressed what it is 2 third parts of; but in respect of its Denomination thirds it is Contract, for it is 2 third Parts, and not 2 fifth Parts, or any other Parts. Lastly, 2 third Parts of a Pound, is Contract, both in respect of its Denomination thirds, and in respect of what they are thirds of.

17. A Decimal Fraction is when the Unit is supposed divided into such a Number of Parts, as may be expressed by an Unit with Cyphers annexed, as 10, 100, 1000, 10000, &c.

18. A Vulgar Fraction admits of any Division of the Unit, as into 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or any other Number of Parts.

19. A Vulgar Fraction is written by two Numbers one above the other, with a Line drawn between them, as  $\frac{3}{4}$ ; the uppermost of which is termed the Numerator, because it Numbers the Parts; the lowest the Denominator,

## Theorems.

For, because it denotes what Parts the Unit is divided into. And therefore,

$\left. \begin{array}{l} 2 \\ 3 \\ 4 \\ 5 \end{array} \right\} \text{ is called } \left\{ \begin{array}{l} 2 \text{ third} \\ 3 \text{ fifth} \\ 4 \text{ eleventh} \\ 5 \text{ ninth} \end{array} \right\}$	$\left. \begin{array}{l} 2 \\ 3 \\ 4 \\ 5 \end{array} \right\} \text{ parts, or } \left\{ \begin{array}{l} 2 \text{ thirds.} \\ 3 \text{ fifths} \\ 4 \text{ elevenths.} \\ 5 \text{ ninths.} \end{array} \right\}$
--	---

But since 3 fifths are equal to one fifth, and one fifth, and one fifth, or a fifth of one, and a fifth of one, and a fifth of one, that is, a fifth of three ones; it follows, that 3 fifths are equal to a fifth of 3, or 3 divided by 5; and so the foregoing Fractions may be read, A third of 2, a fifth of 3, an eleventh of 4, a ninth of 5; or 2 divided by 3, 3 divided by 5, 4 divided by 11, 5 divided by 9.

20. A Single Fraction is such, as denotes a Part or Parts of some Whole.

21. A Compound Fraction is such, as denotes a Part or Parts of some Part or Parts.

So  $\frac{1}{2}$  and  $\frac{2}{3}$  are single Fractions; but  $\frac{1}{2}$  of  $\frac{2}{3}$  and  $\frac{2}{3}$  of  $\frac{1}{2}$  are compound Fractions.

22. A Proper Fraction is less than an Unit.

23. An Improper Fraction is greater than an Unit.

## S E C T. II.

### T H E O R E M S.

1. IF the two right-hand Figures of any Number are measurable by 4, the whole Number is measurable by 4.

2. If the three right-hand Figures of any Number are measurable by 8, the whole is measurable by 8.

3. If the Sum of the Figures constituting any Number, is a Multiple of 3 or 9, then the whole Number is accordingly a Multiple of 3 or 9.

4. If the right-hand place of any Number be a Cypher, or 5, the whole is a Multiple of 5.

5. If the right-hand place of any Number be a Cypher, the whole is a Multiple of 10.

6. If a Number cannot be divided by some prime Number, not greater than the Square Root thereof, that Number is a Prime.

7. If two Fractions are equal to one another, the Numerator of the one is in such Proportion to its Denominator, as the Numerator of the other to its Denominator.

8. If the Numerator of a Fraction be less than the Denominator, that Fraction is a proper one.

9. But if the Numerator be equal or greater than the Denominator, the Fraction is Improper.

10. Every whole Number may be expressed in the Form of a vulgar Fraction, without altering its Value, if that whole Number be the Numerator, and Unity the Denominator.

### **S E C T. III.**

*To find all the PRIMES and the COM-  
PONENTS of all the COMPOSITS  
under any given Number. Suppose 1000.*

**F**ROM such a Table as the following, the Problem may be easily solved; for if any Number under that given be sought in the Table, thus, viz. the Hundreds at the Top or Bottom, and the Tens and Units in the Margin, at the

## 6 *Components of Composites.*

Angle of Meeting (which let be called the place of that Number) is found  $p$ , if the Number be a Prime; or its least Component, if the Number be Composite, which if it be dashed, is the Square Root of the Number.

Then divide the Number by its least Component, and use the Quote in like manner.

So 829 is found to be a Prime.

And so 483 is found to be divisible by 3; and 483 divided by 3, quotes 161, which is by the Table a Multiple of 7; and consequently 161 divided by 7, quotes 23, which by the Table is Prime; whence the Components of 483, are 3, 7, 23; but the Place of 841 gives 29 dashed for a Measure, which shews the Quote will be 29; and therefore 841 is composed of 29 and 29.

And thus you may examine all the Numbers under 1000, the Table reaching only so far.

All even Numbers must be first divided by 2 continually, as oft as possible, and all Numbers ending in 5, divided by 5 as oft as possible, and the Results then sought in the Table, as before.

So 616 divided by 2 three times, quotes 77, which by the Table gives 7 for a Measure, and so the Quote is 11, which by the Table is Prime; consequently the Components of 616, are 2, 2, 2, 7, 11.

And so 435 divided by 5, quotes 87, which by the Table gives 3 for a Measure, and so the Quote 29 is a Prime; whence 435 is composed of 5, 3, 29.

But the Calculating of such a Table being not difficult, I shall next shew the Method to make it.

Let the Paper be first ruled with as many Columns as the limiting Number contains Hundreds, then number the Hundreds at Top and Bot-

	0	1	2	3	4	5	6	7	8	9	
1											1
3		p	p	3	7	p	3	p	p	3	3
7		p	p	3	p	13	3	p	7	3	7
9		p	p	11	3	p	p	3	p	p	9
11		p	3	p	p	3	7	13	3	p	11
13		p	p	3	p	7	3	p	23	3	13
17		p	3	7	p	3	11	p	3	19	17
19		p	7	3	11	p	3	p	p	3	19
21		3	11	13	3	p	p	3	7	p	21
23		p	3	p	17	3	p	7	3	p	23
27		3	p	p	3	7	17	3	p	p	27
29		p	3	p	7	3	17	3	p	p	29
31		p	p	3	p	p	3	p	17	3	31
33		3	7	p	3	p	13	3	p	7	33
37		p	p	3	p	19	3	7	11	3	37
39		3	p	p	3	p	7	3	p	p	39
41		p	3	p	11	3	p	p	3	29	41
43		p	11	3	7	p	3	p	p	3	43
47		p	3	13	p	3	p	p	3	7	47
49		p	p	3	p	p	3	11	7	3	49
51		3	p	p	3	11	19	3	p	23	51
53		p	3	11	p	3	7	p	3	p	53
57		3	p	p	3	p	p	3	p	p	57
59		p	3	7	p	3	13	p	3	p	59
61		p	7	3	19	p	3	p	p	3	61
63		3	p	p	3	p	p	3	7	p	63
67		p	p	3	p	p	3	23	3	3	67
69		3	11	p	3	7	p	3	p	11	69
71		p	3	p	7	3	p	11	3	13	71
73		p	p	3	p	11	3	p	p	3	73
77		7	3	p	13	3	p	p	3	p	77
79		p	p	3	p	3	7	19	3	11	79
81		3	p	p	3	13	7	3	11	p	81
83		p	3	p	p	3	11	p	3	p	83
87		3	11	7	3	p	p	3	p	p	87
89		p	3	17	p	3	19	13	3	7	89
91		7	p	3	17	p	3	p	7	3	91
93		3	p	p	3	17	p	3	13	19	93
97		p	p	3	p	7	3	17	p	3	97
99		3	p	13	3	p	p	3	17	29	99

## 8 *Components of Composites..*

Bottom, and the Tens and Units in the Margins, as in the Example before you.

*First*, Then in the place of the first odd Prime 3, put  $p$ ; and then raise 3 to all its Powers under 1000, the Number given; and in the place of 9, its Square, place 3 with a Dash, thus 3; but in the Places of all its superior Powers, put 3 without the Dash.

*Secondly*, The next odd Number is 5, which is passed by, because all its Multiples end in 5.

*Thirdly*, The next odd Number is 7, whose place is yet vacant, and is therefore to have  $p$  in it; then multiply the Numbers belonging to every place that is filled, by 7 (except such as give Products greater than the limiting Number,) and in the place for the Product, put the Figure that was in the place of the Multiplicand, without a Dash, if it had one; or else the Multiplicand itself, if it be a Prime. Then in the place of the Square of 7, put 7 with a Dash, as 7; and by that Square multiply the same Multiplicands, putting in the places of the Products as before. But in the places of the Powers of 7, put 7 without a Dash; and by these Powers multiply the same Multiplicand, putting in the places of the Products as before.

*Fourthly*, The next odd Number is 9, whose place is filled, and therefore to be pass'd over.

*Fifthly*, The next odd Number is 11, whose place is yet vacant, and is therefore to have  $p$  in it; then by 11, multiply the Numbers belonging to every place that is filled, except such as give Products greater than the limiting Number, and in the place for the Product, put the Figure that was in the place of the Multiplicand, without a Dash, if it had one, or else the Multiplicand itself, if it be a Prime; then in the place of the Square of 11, put 11 with a Dash, and by the



## Components of Composites. 9

the Square and the other Powers of 11, multiply the same Multiplicands, putting in the places of the Products as before; and so use 13, 17, 19, 23, &c. omitting 15, 21, 25, 27, &c.

This Table is continued to 100000 in Dr. Pell's Edition of *Branner's Algebra*, and from thence transcribed into Dr. *Harris's Lexicon*, Vol. 2.

### S E C T. IV.

*To reduce any Number given, into its*  
C O M P O N E N T P R I M E S.

#### The RULE.

**D**ivide the Number given by 2 continually as oft as possible, without a Remainder, and so the Result by 3 as oft as possible, and this last Result by 5 as oft, and so on by 7, 11, 13, &c. all the Prime Numbers, till there arise a Quotient less than the Divisor; and then the Divisors and the last Dividend are the Primes composing the Number given. *e.g.*

Reduce 122760, to its component Primes.

$$2) 122760$$

$$2) 61380$$

$$2) 30690$$

$$3) 15345$$

$$3) 5115$$

$$5) 1705$$

$$11) 341$$

$$31$$

Answer 2, 2, 2, 3, 3, 5, 11, 31.

In the Operation I have omitted the Division by 7, because it would not measure 341; and  
C after-

## 10      *Of Constituent Primes.*

afterwards omitted dividing by 13 and 17, because they are no aliquot Parts of 31.

Reduce 360 to its constituent Primes.

$$2) 360$$

$$2) 180$$

$$2) 90$$

$$3) 45$$

$$3) 15$$

$$5$$

Answer 2, 2, 2, 3, 3, 5.

## S E C T. V.

*To find all the just DIVISORS to any Number.*

### The RULE.

**M**AKE as many Columns as there are different Component Primes in the given Number: And at the Head of each Column, place each Prime, and where there are more than one Prime of the same sort, place in the same Column the Powers of that Prime, till the Index of the last Power be the Number of those like Component Primes; lastly, multiply every Number in the first Column, by every Number in the second, placing each Product in the second; and then every Number in the first and second by every Number in the third, placing each Product in the third, and so with the 4th, 5th, &c. Columns, till all are thus used.

And so shall all the Numbers in these several Columns, be all the Divisors; *e.g.*

To

# Of Divisors and aliquot Parts. 11

To find all the just Divisors of 360,

2	360	2	3	8
2	180	4	9	10
2	90	8	6	20
3	45		12	40
3	15		24	15
	5		18	45
			36	30
			72	60
				120
				90
				180
				360

Answer, 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30, 36, 40, 45, 60, 72, 90, 120, 180, 360,

## S E C T. VI

To find all the ALIQUOT PARTS of any Number given.

**F**IRST, by *Sec. 4.* find all the just Divisors of the Number given, excluding the Number itself, which Divisors with Unity, are all the aliquot Parts.

So all the aliquot Parts of 360, are 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30, 36, 40, 45, 60, 72, 90, 120, 180,

## S E C T. VII.

To find as many PERFECT NUMBERS  
as you please.

**T**AKE any such Power of 2, as being lessened by an Unit, leaves a Prime Number, and multiply that Remainder by half that Power, and the Product is a perfect Number.

	Ex. 1.	Ex. 2.	Ex. 3.	Ex. 4.
2	4	8	16	32
	1	1	1	1
	<hr/>	<hr/>	<hr/>	<hr/>
	3	7	15	31
	2	4		16
	<hr/>	<hr/>		<hr/>
	6	28		496
	Ex. 5.	Ex. 6.	Ex. 7.	
	64	128	256	
	1	1	1	
	<hr/>	<hr/>	<hr/>	
	63	127	255	
		64		
		<hr/>		
		508		
		762		
		<hr/>		
		8128		

So 6, 28, 496, 8128, are perfect Numbers:  
But because 15, 63, 255, are composed Numbers,  
the Results that would arise by multiplying them  
by 8, 32, 128, would be abounding Numbers.

SECT. VIII.

*Two Numbers being given, to find their  
greatest COMMON MEASURE.*

THE RULE.

**D**ivide the greater by the lesser, and if nothing remain, that lesser Number is the greatest common Measure required; but if there be a Remainder, divide the last Divisor by that Remainder; and if there be still a Remainder, divide the last Divisor by the last Remainder; and so proceed till you come to a Division without a Remainder; and then the last Divisor is the greatest common Measure.

Ex. 1. What is the greatest common Measure of 612, and 540?

$$\begin{array}{r}
 540 \overline{) 612} \text{ (1} \\
 \underline{540} \phantom{00} \\
 72 \phantom{00} \text{ (7} \\
 \underline{504} \phantom{00} \\
 36 \phantom{00} \text{ (2} \\
 \underline{72} \phantom{00} \\
 0
 \end{array}
 \quad \text{Answer 36.}$$

But the foregoing Operation may be conveniently placed, thus.

$$\begin{array}{r|l}
 612 & 1 \\
 \hline
 540 & 7 \\
 \hline
 72 & 2 \\
 \hline
 36 & 
 \end{array}$$

## 14 Of Common Measures.

Ex. 2. What is the greatest common Measure of 720 and 336?

$$336) 720 (2$$

$$48) 336 (7 \text{ Or thus,}$$

...

$$\begin{array}{r} 720 \overline{) 2} \\ 336 \overline{) 7} \\ \hline 48 \end{array}$$

Answer, 48.

Ex. 3. What is the greatest common Measure of 360 and 24?

$$24) 360 (15$$

$$120$$

...

Or thus,

$$\begin{array}{r} 360 \overline{) 15} \\ 24 \overline{) 24} \\ \hline 120 \overline{) 120} \\ \hline \end{array}$$

Answer 24.

Ex. 4. What is the greatest common Measure of 643536 and 4500?

$$4500) 643536 (143$$

$$19353$$

$$13536$$

$$36) 4500 (125$$

$$90$$

$$180$$

...

Or thus,

$$\begin{array}{r} 643536 \overline{) 143} \\ 4500 \overline{) 125} \\ \hline 19353 \\ 13536 \\ \hline 36 \\ \hline 90 \\ 180 \\ \hline \end{array}$$

$$19353$$

$$13536$$

$$36$$

$$90$$

$$180$$

$$...$$

Ex. 5.

# Of Common Measures. 15

Ex. 5. What is the greatest common Measure of 3187 and 1111?

$$\begin{array}{r}
 1111)3187(2 \\
 \underline{2222} \\
 965)1111(1 \\
 \underline{965} \\
 146)965(6 \\
 \underline{876} \\
 89)146(1 \\
 \underline{89} \\
 57)89(1 \\
 \underline{57} \\
 32)57(1 \\
 \underline{32} \\
 25)32(1 \\
 \underline{25} \\
 7)25(3 \\
 \underline{21} \\
 4)7(1 \\
 \underline{4} \\
 3)4(1 \\
 \underline{3} \\
 1)3(3 \\
 \underline{3}
 \end{array}$$

Or thus,

$$\begin{array}{r}
 3187 \overline{) 3} \\
 \underline{1111} \quad 1 \\
 965 \overline{) 6} \\
 \underline{146} \quad 1 \\
 \underline{89} \quad 1 \\
 \underline{57} \quad 1 \\
 \underline{32} \quad 1 \\
 \underline{25} \quad 3 \\
 \underline{7} \quad 1 \\
 \underline{4} \quad 1 \\
 \underline{3} \quad 3 \\
 1
 \end{array}$$

The Numbers are prime to one another, for the Answer is 1.

SECT.

## S E C T. IX.

*Two or more Numbers being given, to find a  
COMMON MULTIPLE to them.*

## The R U L E.

**M**ultiply all the Numbers continually, and the Product is the Number sought.

*Ex.* Find a common Multiple to 3, 5, 6, and 9.

$$\begin{array}{r}
 3 \\
 \times 5 \\
 \hline
 15 \\
 \times 6 \\
 \hline
 90 \\
 \times 9 \\
 \hline
 810
 \end{array}$$

Answer 810.

## S E C T. X.

*Two Numbers being given, to find their  
least COMMON MULTIPLE.*

## The R U L E.

**F**IRST find their greatest common Measure, then divide either of the Numbers by that Measure, and multiply the Quotient by the other of those Numbers, and the Product is the Number sought.

*Ex.*



# Of Common Multiples

67

Ex. What is the least common Multiple of 24 and 32?

$$\begin{array}{r|l} 32 & 1 \\ 24 & 3 \\ \hline 8 & \end{array} \quad \begin{array}{r} 8) 32 ( 4 \\ \underline{24} \\ 8 \\ \underline{8} \\ 0 \end{array}$$

96 The Answer.

Ex. 2. What is the least common Multiple of 18 and 49?

$$\begin{array}{r|l} 49 & 2 \\ 18 & 1 \\ 13 & 2 \\ 5 & 1 \\ 3 & 1 \\ 2 & \\ 1 & \end{array} \quad \begin{array}{r} 1) 49 ( 49 \\ \underline{18} \\ 392 \\ \underline{49} \\ 882 \end{array}$$

882 The Answer.

Hence it appears, that the least common Multiple to two Numbers prime to one another is their Product.

## S E C T. II.

Three or more Numbers being given, to find their least COMMON MULTIPLE.

### The RULE.

First find the least common Multiple to two of them, and then to this Multiple, and the third Number, find the least common Multiple; then to the last Multiple and the 4th Number proposed, find the least common Multiple; and so proceed with the 5th, 6th, &c. given Numbers, till

till the last is thus used; And to the Multiple thus found shall be that required.

**Ex. 1.** What is the least Multiple to 8, 12, 9, 15?

$$\begin{array}{r} 12 \overline{) 1} \\ 8 \overline{) 2} \\ 4 \overline{) 3} \end{array}$$

$$\begin{array}{r} 24 \overline{) 1} \\ 9 \overline{) 2} \\ 6 \overline{) 3} \end{array}$$

$$\begin{array}{r} 72 \overline{) 4} \\ 15 \overline{) 2} \\ 12 \overline{) 4} \\ 3 \overline{) 1} \end{array}$$

$$\begin{array}{r} 4 \overline{) 12} (3 \\ 8 \\ \hline 24 \end{array}$$

$$\begin{array}{r} 3 \overline{) 24} (8 \\ 9 \\ \hline 72 \end{array}$$

$$\begin{array}{r} 3 \overline{) 72} (24 \\ 15 \\ \hline 120 \\ 24 \\ \hline 360 \end{array}$$

The Answer.

But if either of the Numbers proposed is an aliquot Part of another of them, that aliquot Part may be omitted in the Work.

**Ex. 2.** What is the least Common Multiple to 4, 3, 6, 8, 12, 9?

$$\begin{array}{r} 12 \overline{) 1} \\ 8 \overline{) 2} \\ 6 \overline{) 3} \end{array}$$

$$\begin{array}{r} 24 \overline{) 1} \\ 9 \overline{) 2} \\ 6 \overline{) 3} \end{array}$$

$$\begin{array}{r} 4 \overline{) 8} (2 \\ 8 \\ \hline 24 \end{array}$$

$$\begin{array}{r} 3 \overline{) 24} (8 \\ 9 \\ \hline 72 \end{array}$$

The Answer.

Here

## Of Common Multiples.

19

Here 4, 3, and 8 are omitted in the Operation, because 4 and 3 and 8, are Aliquot Parts of 12.

If the least common Multiple to some of the preceding Numbers, is also a Multiple to some of the following Numbers; such following Numbers may be omitted in the Operation.

**Ex. 3.** Find the least common Multiple to 15, and 8, and 12.

$$\begin{array}{r|l} 15 & 1 \\ 8 & 1 \\ 7 & 7 \\ 1 & \end{array} \quad \begin{array}{r|l} 120 & 10 \\ 12 & \end{array}$$

$$\begin{array}{r} 15 \\ 8 \\ \hline 120 \end{array}$$

Answer 120.

The Work of this Section may be otherwise performed thus:

If the second be composed to the first, divide the 2d by their greatest common Measure, and cancel it, and place the Quote beneath it; if the 3d be composed to either or both of the preceding uncancell'd Figures, divide it by their greatest common Measure continually, placing the Quotes beneath it, and cancel it and all its Quotes except the last; and so if the 4th be composed to any or all the preceding uncancell'd Figures, divide it by their greatest common Measures continually, placing the Quotes beneath it under one another, and cancelling it and all its Quotes but the last; and thus proceed till you have thus used all the Numbers proposed. And then the Product made by the continual Multiplication of all those uncanceled Numbers, is the Number sought.

# Of Common Multiples.

But in this Method likewise, the Numbers that are aliquot Parts of others may be omitted. And so the Work of the two first Examples will stand thus.

Ex. 1. 8 12 9 15 8

3 3 5

3

24

3

72

5

360 The Answer.

Ex. 2. 4 3 6 8 12 9 8

3 3

3

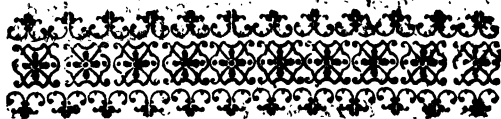
24

3

72 The Answer.

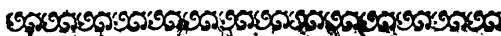


CHAP.



## CHAP. II.

### *Reduction of Fractions.*



#### S E C T. I.

*To Reduce FRACTIONS to their least Terms,*

The RULE.



**D**IVIDE both Terms by their greatest common Measure, and the Fraction formed by their Quotients, is the Answer.

Reduce  $\frac{540}{612}$  to its least Terms.

$$\begin{array}{r|l} 612 & 1 \\ \hline 540 & 7 \\ \hline 72 & 2 \\ \hline 36 & \\ \hline 7 & \end{array}$$

$$\begin{array}{r} 180 \\ 36 \overline{) 540} \end{array} \quad \begin{array}{l} 180 \\ 36 \overline{) 612} \end{array} \quad \left( \frac{5}{12} \right) \text{ The Answer.}$$

Reduce

## 22 Compound to single Fractions.

Reduce  $\frac{1111}{1111}$  to its least Terms.

$$\begin{array}{r} 3184 \overline{) 1111} \end{array}$$

$$\begin{array}{r} 1111 \overline{) 1111} \end{array}$$

$$\begin{array}{r} 985 \overline{) 1111} \end{array}$$

$$\begin{array}{r} 146 \overline{) 985} \end{array}$$

$$\begin{array}{r} 89 \overline{) 146} \end{array}$$

$$\begin{array}{r} 57 \overline{) 89} \end{array}$$

$$\begin{array}{r} 32 \overline{) 57} \end{array}$$

$$\begin{array}{r} 25 \overline{) 32} \end{array}$$

$$\begin{array}{r} 7 \overline{) 25} \end{array}$$

$$\begin{array}{r} 4 \overline{) 7} \end{array}$$

$$\begin{array}{r} 3 \overline{) 4} \end{array}$$

$$\begin{array}{r} 1 \overline{) 3} \end{array}$$

The Answer.

Hence if the Terms are prime to one another, the Fraction is in its least Terms already.

## S E C T. II.

To reduce compound to single FRACTIONS.

The RULE.

**M**ULTIPLY all the Numerators together continually, and the Product is the Numerator of the Fraction sought; and all the Denominators together for the Denominator.

Reduce  $\frac{1}{2}$  of  $\frac{1}{3}$  of  $\frac{1}{4}$  to a single Fraction.

$$\begin{array}{r} 1 \times 1 \times 1 \\ 2 \times 3 \times 4 \\ \hline 1 \\ 24 \end{array}$$

Answer  $\frac{1}{24}$ .

If

## Compound to single Fractions. 23

If the Answer be required in its least Terms: Observe, that if any Numerator be equal to any Denominator, reject them, and conceive Unity in their stead: Or if any Numerator be composed to any Denominator, divide such Numerator and Denominator by their greatest common Measure, and use the Quotients in their stead.

And so the Work of the foregoing Example will stand thus.

$$\frac{1}{2} \text{ of } \frac{5}{6} \text{ of } \frac{3}{4} \text{ of } \frac{2}{3} = \frac{1}{5} \frac{6}{5} \frac{4}{24}$$

Answer  $\frac{1}{5}$ .

Reduce  $\frac{15}{18}$  of  $\frac{2}{3}$  of  $\frac{14}{15}$  to the least single Fraction.

$$\frac{15}{18} \text{ of } \frac{2}{3} \text{ of } \frac{14}{15} = \frac{1}{3} \frac{5}{3} \frac{4}{25}$$

Answer  $\frac{4}{15}$ .

In this Example 15 is composed to 25, and 4 is their greatest common Measure, and so the Quotients are 3 and 5; 2 is composed to 16, and 2 is their greatest common Measure, and so 1 and 8 are the Quotients; 14 and 7 are composed to one another, and 7 is their greatest common Measure, and so the Quotients are 2 and 1; lastly, the 2 over the 14, and the 8 under the 16 are composed to one another, and 2 is their greatest

## §4 Compound to single Fractions.

Let common Measures, and some Quotients be 2 and 4; so that now among the Numerators are found uncancelled 3, 1, 1, 1, and among the Denominators 4, 1, 2, 4, which by the Rule form the Fraction  $\frac{3}{4}$ , which is the least single Fraction that the foregoing Compound one is reducible to.

Reduce  $\frac{2}{3}$  of  $\frac{8}{6}$  of  $\frac{3}{8}$  of  $\frac{1}{4}$  of  $\frac{7}{28}$  of  $\frac{4}{24}$  to the least single Fraction possible.

$$\frac{2}{3} \text{ of } \frac{8}{6} \text{ of } \frac{3}{8} \text{ of } \frac{1}{4} \text{ of } \frac{7}{28} \text{ of } \frac{4}{24}$$

$$\quad \quad \quad 2 \quad \quad 2 \quad \quad 5 \quad \quad 1$$

Answer  $\frac{1}{12}$ .

If it be objected that the finding of the greatest common Measure so often is more Trouble than to form the Fraction after the usual Method, and then at one Operation to find the greatest common Measure, and so reduce it to its least Terms; it may be answered, that such greatest common Measures in small Numbers (as most Fractions are usually proposed in before they are moulded together) appear upon View to any one that is but a little acquainted with Numbers; but some common Measures, if not the greatest, will easily appear even in large Numbers most commonly; and by using those Measures, the Quotes are smaller, and so other Measures may appear, and thus very often the least Quotes may be found; or at least the Fraction will hereby be found in lower Terms.



## To reduce mix'd Numbers, &c. 49

Indeed if no such common Measure do appear upon View, the best way is to work as usual, and then to reduce it as in the last Section.

There is a Set of Fractions often come to hand, whose Terms are Fractions or mix'd Numbers, as  $\frac{72 \frac{43}{7}}{19 \frac{7}{7}}$ , and might properly be called

Compound ones, if that Name had not been already given to the foregoing sort: How to use such, you will find at the 1<sup>st</sup> Section of the 7<sup>th</sup> Chapter.

## SECT. III.

### To reduce mix'd Numbers to improper FRACTIONS.

#### The RULE.

**M**ultiply the whole Number by the Denominator of the Fraction; and to the Product add the Numerator, and the Sum is the Numerator of the Fraction sought, and the given Denominator is the Denominator sought.

Reduce  $47 \frac{3147}{397947}$  to an improper Fraction.

$$\begin{array}{r}
 47 \\
 \times 397947 \\
 \hline
 3400 \\
 38800 \\
 370 \\
 3147 \\
 \hline
 397947
 \end{array}
 \quad
 \begin{array}{r}
 47 \\
 \times 397947 \\
 \hline
 3400 \\
 38800 \\
 370 \\
 3147 \\
 \hline
 397947
 \end{array}
 \quad
 \text{Answer } 127247$$

## 26. To reduce improper Fractions

### SECTION VI.

To reduce improper FRACTIONS to whole or mix'd Numbers.

#### THE RULE.

**D**ivide the Numerator by the Denominator, and the Quotient is the whole Number; and if there be a Remainder, it is the Numerator of the Fraction to be annexed, whose Denominator is the Denominator given.

Reduce  $\frac{227247}{47}$  to its equivalent whole or mix'd Number.

8400) 397947 (47

619

3147

Answer 47  $\frac{3147}{47}$

Reduce  $\frac{11}{47}$  to its equivalent whole or mix'd Number.

11) 11 (1

Answer 1

If the fractional Part of the Answer be not in its least Terms, it may be convenient to reduce it to such; for the ready Performance whereof, observe the following Work.

Reduce

# To other Denominations. 27

Reduce  $\frac{169}{11}$  to its equivalent whole or mix'd Number in its least Terms.

1690 | 11 1540    150  
 221 | 1    13  
 143 | 1    132  
 78 | 1    130  
 64 | 1    126  
 12 | 1    124  
 Answer 7  $\frac{1}{11}$

## SECT. V.

To reduce a FRACTION to any Denomination its capable of, without a mix'd Number, or a FRACTION for its Numerator.

### THE RULE,

**M**ultiply the Numerator by the Denominator of the Fraction sought, and divide that Product by the Denominator of the Fraction given; and so the Quotient, if nothing remain, shall be the Numerator sought; but if there be a Remainder, the Fraction is incapable of that Denomination without a mix'd Number, or a Fraction for its Numerator.

Reduce  $\frac{1}{11}$  to another equal to it, whose Denominator may be 225.

$$\begin{array}{r}
 18 \\
 225 \\
 \hline
 1800 \\
 225 \\
 \hline
 135)4050(30 \\
 \dots 0
 \end{array}$$

E 2

Answer  $\frac{30}{225}$  Reduce

## 28 To reduce improper Fractions

Reduce  $\frac{6}{27}$  to another equal to it whose Denominator may be 27.

$$\begin{array}{r} 6 \\ 27 \overline{) 162} \quad (20 \\ 162 \end{array}$$

From whence it appears that the Numerator will be a mix'd Number, for the full Quote is  $20\frac{2}{3}$ , and so the Fraction sought must be  $20\frac{2}{3}$ .

If the Fraction be in its least Terms, as it ought to be, then divide the Denominator of the Fraction sought, by the Denominator of the Fraction given, and (if there be no Remainder, the Fraction is capable of the required Denomination, otherwise not) then multiply that Quotient by the Numerator of the Fraction given; and so the Product shall be the Numerator of the Fraction sought.

Reduce  $\frac{1}{2}$  to another Fraction equal to it whose Denominator shall be 27.

$$\begin{array}{r} 75 \\ 27 \overline{) 135} \quad (5 \\ 135 \end{array}$$

Answer  $\frac{37}{27}$ .

This Method may be sometimes used, when the Fraction is not in its lowest Terms, viz. When the Denominator of the given Fraction is an aliquot Part of the Denominator of that sought.

Reduce  $\frac{1}{2}$  to another equal to it, whose Denominator shall be 608.

$$\begin{array}{r} 76) 6086 \ 8 \\ \dots \underline{42} \\ 336 \end{array} \quad \text{Answer } 2\frac{11}{16}.$$

But if the Denominator of the given Fraction be an aliquant Part of the other Denominator, and the given Fraction not in its least Terms; The last Method will not so easily give us the Numerator of the Fraction sought, tho' it might be had by the first of this Section; as may appear by the first Example.

## S E C T. VI.

To Reduce FRACTIONS; having unequal Denominators, to others equal in Value, having equal Denominators; usually called reducing them to common Denominators.

### THE RULE.

**M**ultiply all the Denominators together continually, and the Product is the common Denominator, and each Numerator by all the Denominators except its own, and the Products are the required Numerators.

Reduce  $\frac{2}{3}, \frac{5}{4}, \frac{1}{2}$ , to others equal to them, having equal Denominators.

$$\begin{array}{r} 12 \quad 7 \quad 5 \quad 4 \\ \underline{3} \quad \underline{8} \quad \underline{12} \quad \underline{12} \\ 96 \quad 56 \quad 60 \quad 48 \\ \underline{9} \quad \underline{9} \quad \underline{9} \quad \underline{8} \\ 864 \quad 504 \quad 540 \quad 384 \end{array}$$

Answer  $\frac{128}{864}, \frac{140}{504}, \frac{112}{540}, \frac{112}{384}$ .

If

# To reduce Fractions

If the Fractions to be reduced are many, after the common Denominator is found, the Numerators are best found by the Doctrine of the 6th Section.

Reduce  $\frac{7}{9}$ ,  $\frac{5}{11}$ ,  $\frac{35}{9}$ ,  $\frac{9}{11}$ ,  $\frac{7}{11}$ ,  $\frac{1}{11}$  to others equal to them having equal Denominators.

7	7) 630630	9) 630630
5	90090	70070
35	6	4
9	540540	280280

315	8) 630630	11) 630630
11	126126	57339
3465	3	7
13	378378	401310
10395		
3465		

45045	13) 630630 (48510
-------	-------------------

14) 630630 (45045	110	5
180180	66	242550

43645	13) 630630 (48510	
690630	14) 630630 (45045	
	70	9

63	405405
----	--------

Answer  $\frac{7}{9} = \frac{405405}{630630}$ ,  $\frac{5}{11} = \frac{280280}{630630}$ ,  $\frac{35}{9} = \frac{280280}{630630}$ ,  $\frac{9}{11} = \frac{57339}{630630}$ ,  $\frac{7}{11} = \frac{401310}{630630}$ ,  $\frac{1}{11} = \frac{57339}{630630}$

## SECTION VII.

To reduce FRACTIONS, in their least Terms, to their least common Denominators.

The RULE.

FIRST, by the 11th Section of the first Chapter, find the least common Multiple to the Denominators, which shall be the least common

# To common Denominators. 31

tion Denominator; and then, by the 5th Section of this Chapter, find the Numerators.

Reduce  $\frac{2}{3}, \frac{4}{6}, \frac{1}{2}, \frac{1}{3}$  to the least common Denominator possible.

$$\begin{array}{r} 2 \overline{) 12} \quad 4 \overline{) 24} \quad 24 \overline{) 24} \quad 3 \overline{) 24} \\ 8 \quad 8 \quad 9 \quad 8 \\ 4 \quad 16 \quad 6 \quad 16 \\ \hline 4 \quad 8 \quad 18 \quad 16 \end{array}$$

So 72 is the least common Multiple to the Denominator.

Or thus,

$$\begin{array}{r} 8 \times 2 = 16 \quad 4 \times 3 = 12 \quad 4 \times 3 = 12 \quad 8 \\ 3 \quad 3 \quad 3 \quad 3 \\ \hline 24 \quad 12 \quad 12 \quad 24 \\ 3 \quad 3 \quad 3 \quad 3 \\ \hline 72 \end{array}$$

72 as before

Whence the least common Denominator is 72.

$$\begin{array}{r} 8 \overline{) 72} \quad 12 \overline{) 72} \quad 9 \overline{) 72} \quad 3 \overline{) 72} \\ 5 \quad 6 \quad 8 \quad 24 \\ \hline 45 \quad 42 \quad 32 \quad 48 \end{array}$$

$$\begin{array}{r} 6 \overline{) 72} \quad 4 \overline{) 72} \\ 5 \quad 18 \\ \hline 60 \quad 18 \end{array}$$

Answer  $\frac{45}{72}, \frac{42}{72}, \frac{32}{72}, \frac{48}{72}$

In all the Operations of this Chapter, I have set down every single Multiplication or Division to explain the Methods herein made use of; tho' indeed many of them, without any Burthen to the Memory, may be omitted in Practice; and Instance whereof shall be taken from this last Example.

*First*, Any one that is but a little skilled in the preceding Sections, must know, that 4 is the greatest common Measure of 8 and 12, and that 12 divided by 4 quotes 3, which multiplied by 8 produces 24, which is the least common Multiple of 8 and 12.

And also that 3 is the greatest common Measure of 9 and 24; wherefore since 24 divided by 3 quotes 8, and 8 multiplied by 9 produces 72; it follows that 72 is the least common Multiple of 8, 12, 9, and therefore of 3, 6, 4 also; because these are aliquot Parts of 12; consequently, by the Rule, 72 is the least common Denominator.

And then for the Numerators; *first*, 72 divided by 8 quotes 9, which multiplied by 5 produces 45, the Numerator of the first: And in like manner may the Numerator of every Fraction, and consequently every Fraction be formed, without so much as the writing of one single Digit.

And generally all Fractions, that are expressed in small Terms, may be thus reduced.

Hence it appears that the keeping of Fractions in their least Terms, is a very great Advantage in future Operations.





## CHAP. III.

### *Addition of Vulgar FRACTIONS.*



#### SECT. I.

*To collect, or add two or more FRACTIONS together.*

#### THE RULE.



**R**EDUCE the given Fractions, if compound, to single ones, and then to a common Denominator, if they have not such already ; then add up their Numerators, and to the Sum subscribe the common Denominator, which gives the Answer. Then reduce it to its least Terms, and if improper, to its equivalent whole or mix'd Number.

Add  $\frac{2}{12}$ ,  $\frac{3}{12}$  and  $\frac{7}{12}$  together.

$$\begin{array}{r} 2 \\ 3 \\ 7 \\ \hline 12 \end{array} \left. \vphantom{\begin{array}{r} 2 \\ 3 \\ 7 \\ \hline 12 \end{array}} \right\} \text{the Numerators.}$$

Answer  $\frac{12}{12}$ .

F

Add

# 34 Addition of Fractions.

Add  $\frac{3}{8}$  and  $\frac{1}{8}$  together.

$$\begin{array}{r} 3 \\ + 1 \\ \hline 4 \end{array}$$

Answer  $\frac{4}{8}$ , or in its least Terms  $\frac{1}{2}$ .

Add  $\frac{2}{7}$  and  $\frac{3}{7}$  and  $\frac{5}{7}$  together.

$$\begin{array}{r} 2 \\ + 3 \\ + 5 \\ \hline 10 \end{array}$$

Answer  $\frac{10}{7}$ , or its equal  $1 \frac{3}{7}$ .

Add  $\frac{1}{4}$  and  $\frac{2}{5}$  and  $\frac{3}{7}$  together; which reduced, are  $\frac{6}{28}$ ,  $\frac{16}{28}$ ,  $\frac{12}{28}$ .

$$\begin{array}{r} 6 \\ + 16 \\ + 12 \\ \hline 34 \end{array}$$

Answer  $\frac{34}{28}$ , or in a mix'd Number  $1 \frac{11}{7}$ .

Add  $\frac{1}{2}$  of  $\frac{5}{6}$  to  $\frac{2}{3}$  and  $\frac{4}{5}$  and  $\frac{3}{4}$ .

After the improper Fraction is reduced, they are  $\frac{5}{6}$ ,  $\frac{2}{3}$ ,  $\frac{4}{5}$ ,  $\frac{3}{4}$ , and these reduced to a common Denominator, are  $\frac{225}{600}$ ,  $\frac{160}{600}$ ,  $\frac{480}{600}$ ,  $\frac{450}{600}$ .

$$\begin{array}{r} 225 \\ + 160 \\ + 480 \\ + 450 \\ \hline 1315 \end{array}$$

833 Answer  $\frac{1315}{600}$ , or in a mix'd Number  $2 \frac{111}{600}$ .

SECT.

# *Addition of mix'd Numbers, 35*

## S E C T. II.

*To add mix'd NUMBERS together.*

THE RULE,

**F**IRST add up the fractional Part, as taught in the last Section, and if their Total be a proper Fraction subscribe it, and proceed to add up the Integers; but if the total Sum of the Fractions be an improper one, reduce it to its equivalent mix'd Number, and subscribe the fractional Part thereof, but carry the Integers to be added up with the Integral Parts of the given Numbers.

Add  $476\frac{1}{3}$  and  $24\frac{1}{4}$  and  $74\frac{1}{2}$  and  $81\frac{1}{5}$  and  $152\frac{1}{6}$  together.

But when the fractional Parts are reduced to a common Denominator, as taught in the last Section of the second Chapter, they will be as followeth.

$$476 \frac{40}{120}$$

$$24 \frac{30}{120}$$

$$74 \frac{60}{120}$$

$$81 \frac{24}{120}$$

$$152 \frac{20}{120}$$

$$\hline 444 \frac{140}{120}$$

$$809 \frac{100}{120}$$

Sum of the fractional Parts,  
which reduced, is  $2 \frac{11}{60}$

The Answer,

# S E C T. III.

*To add to any FRACTION any Part or Parts of the same FRACTION.*

## The RULE.

**T**O the Numerator of the Fraction, expressing the Part or Parts to be added, add the Denominator, and multiply the Sum by the other Numerator, and this shall be the Numerator of the Answer; lastly, multiply the two Denominators together, and the Product is the Denominator of the Answer.

To  $\frac{2}{7}$  add  $\frac{2}{7}$  of the same  $\frac{1}{4}$ .

$$\begin{array}{r} 2 \\ 7 \\ \hline 9 \\ 3 \\ \hline 27 \end{array} \quad \begin{array}{r} 7 \\ 4 \\ \hline 28 \end{array}$$

Answer  $\frac{27}{28}$ .

Or thus; After the Numerator 2 is increased by its Denominator 7, and so becomes 9, reduce the compound Fraction  $\frac{2}{7}$  of  $\frac{1}{4}$  to a single one, and it is the Answer; for  $\frac{2}{7}$  of  $\frac{1}{4}$  gives  $\frac{2}{28}$ .

To  $\frac{1}{4}$  add  $\frac{2}{7}$  of the same  $\frac{1}{4}$ .

$$\begin{array}{r} 7 \\ 9 \\ \hline 16 \end{array} \quad \begin{array}{r} 1 \\ 4 \\ \hline 4 \end{array} \quad \text{of } \frac{1}{4} \text{ reduced, becomes } \frac{1}{2} \text{ or } 1\frac{1}{2} \text{ the Answ.}$$

SECTION IV.

To add any Parts of any FRACTION to any Parts of the same FRACTION.

The RULE.

**F**IRST add the Parts, as taught in the first Section of this Chapter; and make of the Sum of the Parts and the Fraction a compound Fraction, which reduced to a single one shall be the Answer.

To  $\frac{2}{3}$  of  $\frac{1}{2}$  add  $\frac{1}{3}$  of  $\frac{1}{2}$ .

But the Sum of  $\frac{2}{3}$  and  $\frac{1}{3}$  is  $\frac{1}{1}$ .

And  $\frac{1}{1}$  of  $\frac{1}{2}$  reduced, is  $\frac{1}{2}$  the Answer.



CHAP.



## CHAP. IV.

### *Subtraction of Vulgar Fractions.*



#### SECTION I.

*To subtract one FRACTION from another,*

#### The RULE.



**R**EDUCE the given Fractions, if compound, to single ones, and then to a common Denominator, if they have not such already; lastly, subtract their Numerators, and to the Remainder subscribe the common Denominator, and it is the Answer, which reduce to its least Terms.

From  $\frac{1}{2}$  subtract  $\frac{1}{4}$ .

$$\frac{2}{2} - \frac{1}{4}$$

Answer  $\frac{1}{4}$  or in its least Terms  $\frac{1}{4}$ .

From

## Subtraction of mix'd Numbers. 39

From  $1\frac{1}{2}$  subtract  $\frac{1}{4}$ .

These reduced are  $\frac{3}{4}$  and  $\frac{1}{4}$ .

20

9

11

Answer  $1\frac{1}{4}$

Subtract  $\frac{1}{4}$  of  $\frac{1}{2}$ , or its Equal  $\frac{1}{4}$  from  $\frac{3}{4}$ , but these reduced to a common Denominator are  $\frac{3}{4}$  and  $\frac{1}{4}$ .

And so the Answer is  $\frac{2}{4}$ , or in its least Terms  $\frac{1}{2}$ .

From  $\frac{2}{3}$  of  $\frac{7}{8}$  take  $\frac{1}{4}$  of  $\frac{1}{2}$ ; or when reduced to single Fractions, from  $\frac{7}{12}$  take  $\frac{1}{4}$ , which reduced to a common Denominator, are  $\frac{7}{12}$  and  $\frac{3}{12}$  wherefore the Answer is  $\frac{4}{12}$ .

### SECT. II.

To Subtract MIX'D NUMBERS.

The RULE.

**FIRST** subtract the Fractions according to the Doctrine of the foregoing Section, and then the Integers. But if the fractional Part of the Subtrahend be greater than the fractional Part of the Minuend (and consequently when reduced to a common Denominator, the Numerator of the former, greater than the Numerator of the latter;) then subtract the Numerator of the Subtrahend from the common Denominator, and to the Remainder add the Numerator of the Minuend, and the Sum is the Numerator to the fractional Part of the Answer, to which subscribe the

## Subtraction of mixed Numbers.

the common Denominator; then carry one to the integral Part of the Subtrahend; and subtract.

From  $17\frac{1}{3}$  subtract  $12\frac{2}{3}$ ; or when the Fractions are reduced to a common Denominator, from  $17\frac{10}{15}$  take  $12\frac{8}{15}$ .

$$\begin{array}{r} 17\frac{10}{15} \\ 12\frac{8}{15} \\ \hline 5\frac{2}{15} \end{array} \quad \text{The Answer.}$$

From  $27\frac{3}{4}$  subtract  $15\frac{3}{4}$ ; or from  $27\frac{3}{4}$  take  $15\frac{3}{4}$ .

$$\begin{array}{r} 27\frac{3}{4} \\ 15\frac{3}{4} \\ \hline 11\frac{0}{4} \end{array} \quad \text{The Answer.}$$

From  $14\frac{2}{3}$  subtract  $\frac{1}{3}$ .

These reduced are  $\left\{ \begin{array}{l} 14\frac{4}{6} \\ \frac{2}{6} \end{array} \right.$

$$\begin{array}{r} 14\frac{4}{6} \\ \frac{2}{6} \\ \hline 13\frac{2}{6} \end{array} \quad \text{The Answer.}$$

From 14 subtract  $\frac{5}{8}$ .

$$\begin{array}{r} 14 \\ \frac{5}{8} \\ \hline 9\frac{3}{8} \end{array} \quad \text{The Answer.}$$

From  $14\frac{1}{2}$  subtract 5.

$$\begin{array}{r} 14\frac{1}{2} \\ 5 \\ \hline 9\frac{1}{2} \end{array} \quad \text{The Answer.}$$

From



# Subtraction of Fractions. 41

From 1 subtract  $\frac{7}{11}$ .

$$\begin{array}{r} 1 \\ - \frac{7}{11} \\ \hline \frac{4}{11} \end{array} \text{ The Answer.}$$

From 7 subtract  $\frac{5}{9}$ .

$$\begin{array}{r} 7 \\ - \frac{5}{9} \\ \hline 6\frac{4}{9} \end{array} \text{ The Answer.}$$

## S E C T. III.

*From any FRACTION to subtract any Parts of the same.*

### The RULE.

**F**ROM the Denominator of that Fraction which denotes the Parts to be taken away, subtract its Numerator, and multiply the Remainder by the other Numerator, and this shall be the Numerator of the Answer; lastly, multiply the two Denominators together, and the Product is the Denominator of the Answer.

From  $\frac{3}{7}$  subtract  $\frac{3}{10}$  of  $\frac{1}{7}$ .

$$\begin{array}{r} 10 \quad 10 \\ \frac{3}{7} \quad \frac{7}{70} \\ \hline \frac{5}{35} \end{array} \text{ Answer } \frac{3}{10} \text{ or in its least Terms } \frac{1}{10}.$$

Or thus, after the Denominator 10 is lessened by its Numerator 3, and the Difference 7 made

G

Num.

rator instead of the 3; reduce the compound Fraction  $\frac{1}{2}$  of  $\frac{1}{3}$  to a single one, and it gives  $\frac{1}{6}$  the Answer as before.

## S E C T. IV.

*From any Parts of a FRACTION to subtract any other Parts of the same.*

### The RULE.

**F**IRST subtract the Parts, and with the Remainder and the proposed Fraction form a compound one, which reduced to a single one is the Answer.

From  $\frac{3}{4}$  of  $\frac{1}{2}$  subtract  $\frac{1}{4}$  of the same  $\frac{1}{2}$ .

If  $\frac{1}{4}$  be subtracted from  $\frac{3}{4}$  the Remainder is  $\frac{2}{4}$  and  $\frac{2}{4}$  of  $\frac{1}{2}$  reduced is  $\frac{1}{2}$  the Answer.





## CHAP. V.

### *Multiplication of vulgar Fractions.*



#### The RULE.



**R**EDUCE compound Fractions to single ones, and mix'd Numbers to improper Fractions, and express Integers in the Form of Fractions; then multiply the Numerators of the Factors together, and the Product is the Numerator of the Answer; and likewise the Denominators together, and the Product is Denominator of the Answer.

But observe that the Terms of the Factors may be lessened, by the Directions laid down in *Seet. 3. of Chap. II.* and so the Answer will be in its least Terms, which if an improper Fraction, it is sometimes convenient to reduce to its equivalent whole, or mix'd Number.

*Example 1.* Multiply  $\frac{4}{5}$  by  $\frac{7}{6}$ ,

$$\begin{array}{r} \frac{4}{5} \\ \times \frac{7}{6} \\ \hline \frac{28}{30} \end{array} \quad \begin{array}{r} 7 \\ \frac{2}{63} \end{array} \quad \text{Answer } \frac{28}{63}$$

G 2

Ex.

## 44 Multiplication of vulgar Fractions.

Ex. 2. Multiply  $\frac{3}{9}$  by  $\frac{8}{26}$ .

$$\begin{array}{r} \frac{3}{9} \times \frac{8}{26} \\ \hline \frac{24}{234} \end{array}$$

Answer  $\frac{24}{234}$

Ex. 3. Multiply  $\frac{2}{3}$  by  $\frac{1}{2}$  of  $\frac{8}{8}$ .

$$\frac{2}{3} \text{ by } \frac{1}{2} \text{ of } \frac{8}{8}$$

Answer  $\frac{1}{4}$

Ex. 4. Multiply  $\frac{2}{3}$  by  $\frac{1}{2}$  of  $\frac{9}{12}$ , or  $\frac{2}{3}$  by  $\frac{3}{4}$ .

Answer  $\frac{3}{8}$

Ex. 5. Multiply  $9\frac{2}{3}$  by  $7\frac{1}{2}$ ; or  $\frac{17}{2}$  by  $\frac{15}{2}$ .

$$\begin{array}{r} 9\frac{2}{3} \times 7\frac{1}{2} \\ \hline 66\frac{1}{2} \end{array}$$

Ex. 6. Multiply  $\frac{2}{3}$  by  $7$ , or  $\frac{2}{3}$  by  $7\frac{0}{1}$ .

Answer  $\frac{14}{3}$

Ex. 7. Multiply  $4\frac{2}{3}$  by  $\frac{1}{2}$ , that is  $\frac{14}{3}$  by  $\frac{1}{2}$ , produces  $\frac{7}{3}$  which reduced, is  $2\frac{1}{3}$ .

Ex. 8. Multiply  $\frac{1}{3}$  by  $7\frac{1}{2}$  or  $7\frac{1}{2}$ .

Answer  $2\frac{1}{4}$

But if a mixed Number be to be multiplied by a whole Number, first multiply the fractional Part,

## *Division of vulgar Fractions.* 43

Part, and reduce it to its equivalent mix'd Number, subscribing the fractional Part, but carrying the Integers to the Product of the Integers,

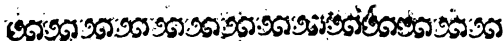
Ex. 9. Multiply  $4\frac{2}{3}$  by 6.

First,  $\frac{2}{3}$  by 6 is  $4$  which reduced is  $2\frac{2}{3}$ , and 4 by 6 is 24, therefore the Product is  $26\frac{2}{3}$ .



## CHAP. VI.

### *Division of vulgar Fractions.*



#### THE RULE.



**R**EDUCE compound Fractions to single ones, and mix'd Numbers to Improper Fractions, and express Integers in the form of a Fraction; then multiply the Numerator of the Dividend by the Denominator of the Divisor, and the Product is the Numerator of the Quotient; and multiply the Denominator of the Dividend by the Numerator of the Divisor, and the Product is the Denominator of the Quotient. But observe, that if the Numerators of the given Fractions are composed to one another, they may be divided by their greatest common Measure; or if the Denominators are composed to one another, they

## 46 Division of vulgar Fractions.

they may be divided by their greatest common Measure, and use these Quotients in their stead. And so the Fraction sought will be had in its least Terms.

Ex. 1. Divide  $\frac{2}{3}$  by  $\frac{1}{4}$ .

$$\frac{2}{3} \div \frac{1}{4} = \frac{8}{3}$$

Ex. 2. Divide  $\frac{24}{49}$  by  $\frac{2}{14}$ .

$$\frac{24}{49} \div \frac{2}{14} = \frac{16}{7}$$

Ex. 3. Divide  $\frac{1}{8}$  by  $\frac{3}{4}$  of  $\frac{1}{2}$ , that is, when reduced  $\frac{1}{8}$  by  $\frac{3}{8}$ .

$$\frac{1}{8} \div \frac{3}{8} = \frac{1}{3}$$

Ex. 4. Divide  $68\frac{1}{4}$  by  $9\frac{1}{3}$ , that is  $\frac{271}{4}$  by  $\frac{28}{3}$ .

$$\frac{271}{4} \div \frac{28}{3} = \frac{1034}{112} = 9\frac{1}{4}$$

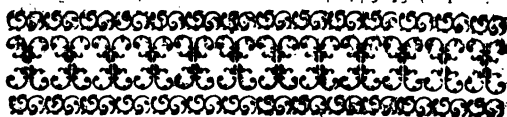
Which reduced, is  $9\frac{1}{4}$ .

Ex. 5. Divide  $\frac{14}{33}$  by  $7\frac{1}{3}$ , that is  $\frac{14}{33}$  by  $\frac{22}{3}$ .

$$\frac{14}{33} \div \frac{22}{3} = \frac{2}{11}$$

Ex. 5. Divide 9 by  $\frac{3}{5}$ .

$$9 \div \frac{3}{5} = 15$$



## CHAP. VII.

*The managing such Fractions that have their Terms mix'd Numbers, or Fractions. The valuing any assigned Parts of any contract Number propos'd, and its Converses. The Extraction of the Roots of Fractions.*



### SECT. I.

*To reduce a FRACTION, that bath its Terms mix'd Numbers or FRACTIONS, to another that bath its Terms Integers.*

**The RULE.**



ACCORDING to the Rules laid down in Division, divide the Numerator by the Denominator, and the Quotient is the Answer.

**Ex. 1.** Reduce  $\frac{72\frac{1}{2}}{19\frac{2}{3}}$  to a Fraction, whose Terms are Integers. 19

## To reduce Fractional Terms 148

but these reduced, are  $\frac{1}{2}, \frac{1}{3}, \frac{1}{4}$  which quotes  $\frac{1}{12}$ .

Ex. 2. Reduce the Terms of this Fraction  $\frac{4}{\frac{1}{2}}$  to Integers.

Ans.  $\frac{4}{\frac{1}{2}} = 4 \div \frac{1}{2} = 4 \times \frac{2}{1} = 8$  The Answer.

Ex. 3. Reduce  $\frac{3}{\frac{1}{4}}$  to a Fraction whose Terms are Integers.

Ans.  $\frac{3}{\frac{1}{4}} = 3 \div \frac{1}{4} = 3 \times \frac{4}{1} = 12$  The Answer.

Ex. 4. Reduce  $\frac{3}{\frac{1}{7}}$  to a Fraction whose Terms are Integers.

Ans.  $\frac{3}{\frac{1}{7}} = 3 \div \frac{1}{7} = 3 \times \frac{7}{1} = 21$  The Answer.

Ex. 5. Reduce  $\frac{4}{\frac{1}{5}}$  to a Fraction whose Terms are Integers.

Ans.  $\frac{4}{\frac{1}{5}} = 4 \div \frac{1}{5} = 4 \times \frac{5}{1} = 20$  The Answer.

Which requires the dividing of  $4\frac{2}{5}$  by  $3\frac{1}{5}$ .

Where the fractional Part of the Divisor is  $\frac{1}{5}$  which reduced according to the Rule is  $\frac{1}{5}$  and



**S** To value fractional Parts, &c. 49  
 and the fractional Part of the Dividend is  $\frac{2\frac{1}{2}}{5\frac{1}{3}}$  which reduced is  $\frac{7}{15}$ : Therefore the Division now is  $3\frac{2}{3}) 4\frac{1}{3} ($  And so the Answer according to the Rules of Division is  $1\frac{2}{3}$ .

Hence it appears, how Fractions of howsoever complex a Nature, may be reduced to others of the most simple kind, viz. such as have their Terms Integers: And then they are fitted for the foregoing Rules.

## S E C T. II.

To value any fractional Part or Parts of any CONTRACT NUMBER proposed.

### The R U L E.

**L** E T the proposed Number be reduced to the least Denomination therein express'd; then multiply it by the Numerator of the Fraction denoting the Parts, and divide the Product by the Denominator, and the Quotient, if nothing remain, is the Answer of the same Denomination; the contract Number was last reduced to: But if any thing remain, reduce it to the next lower Denomination, and then divide it by the same Divisor, and so the Quotient is another part of the Answer of the last Denomination, to be connected with the foregoing: And if there be still a Remainder, reduce and divide till you come to your desired Exactness: But lastly, if the Remainder's Name is the least that the contract Number is usually reduced to, and yet an exact Answer is sought for; make the Remainder the  
 Denominator, Numerator,

59 To value fractional Parts

Numerator, and the Divisor the Denominator of a Fraction, to be annexed to the foregoing Value.

*Example.* What is  $\frac{1}{4}$  of 7 C. wt. and 3 grs.?

$$\begin{array}{r} 18 \\ 24 \overline{) 341} 14 \\ \underline{101} \\ 5 \\ 28 \end{array}$$

$$\begin{array}{r} 24 \overline{) 140} 5 \\ \underline{20} \end{array}$$

Hence the Answer is  $14\ 5\ \frac{2}{3}$ .  
But if the Quarters are reduced  
to Hundred Weights, and the  
Fraction to its least Terms, the

**C. wt. qrs. lb.**  
**Answer is**     3   2   5   5.

**Ex. 2.** What is  $\frac{2}{3}$  of  $14 \frac{5}{6}$ ?

$$\begin{array}{r} 14 \text{ } 5 \text{ } \frac{1}{2} \\ 12 \\ \hline 173 \\ 2 \\ \hline 347 \end{array}$$

$$\begin{array}{r} 22 \\ \times 32 \\ \hline 694 \\ 694 \\ \hline \end{array}$$

25) 7634(3054) half-pence, op.

134

$$9 \dots 12.8 \frac{17}{2}.$$

If the Numerator of the Fraction proposed, be so small that the contraſt Number may be multiplied by it without Reduction: Then divide the higher part of the Product by the Denominator, and

## Of contract Numbers. 51

and the Quote is that part of the Answer that is of that Name; then reduce the Remainder to the next inferiour Name, and add thereto all that are of the same in the preceding Product, and divide this Sum by the same Divisor, and the Quote is another part of the Answer, of the same Name with the last Dividend: Thus proceed to your lowest Denomination, and if any thing still remain, express it as in the foregoing Operations.

Ex. 3. What is  $\frac{7}{13}$  of  $\overset{l. s. d.}{5\ 7\ 6}$ ?

$$\begin{array}{r}
 \overset{l. s. d.}{5\ 7\ 6} \\
 \underline{7\ l. s. d.} \\
 23) 37\ 12\ 6\ (1\ 12\ 8\ \frac{14}{13} \text{ The Answer} \\
 \underline{14} \\
 20 \\
 23) 292 \\
 \underline{62} \\
 16 \\
 \underline{12} \\
 23) 198 \\
 \underline{14}
 \end{array}$$

But if the Numerator be not a single Digit, yet if it be the Product of two Digits, multiply the contract Number by one of these Digits, and the Product by the other, and this last Product is that made by multiplying the contract Number by the Numerator, which divide as in the last.

l. s. d.

Ex. 4. What is  $\frac{42}{11}$  of 14 11 7  $\frac{1}{2}$ ?87 09 7  $\frac{1}{2}$ 87 09 7  $\frac{1}{2}$ 

l. s. d. q.

87 09 7  $\frac{1}{2}$  12 0 1 2  $\frac{1}{2}$ 

The Answer.

20

12

12

88

37

4

150

48

Hence it appears convenient to reduce the Fraction to its least Terms, if it be not so already.

If the Numerator be not the Product of two single Digits, but differing from such a Product by a single Digit, first multiply the contract Number by that Product, and then the same contract Number by the Difference between the Product of the two Digits and the Numerator, and lastly, if the Numerator be greater than the Product of the two Digits, add, if less, subtract the latter Product (arising from the contract Number) from the former; and then work as in the last.

Ex.

Ex. 5. What is  $\frac{19}{101}$  of 37 15 03  $\frac{1}{4}$ ?

1. s. d.  $\frac{19}{101}$  00 78  
 37 15 03  $\frac{1}{4}$   
264 06 10  $\frac{1}{4}$  The whole by 7  
 2114 15 02 } That Product by 8, equal to  
 113 05 09  $\frac{1}{4}$  } the whole by 56.  
 101)2228 00 11  $\frac{1}{4}$  (22 01 202 1  $\frac{19}{101}$   
 208  
 6

20 l. s. d.  
 120 37 15 03  $\frac{1}{4}$   
 19 63 Or 9 times 7  
 12 339 17 05  $\frac{1}{4}$   
 239 2379 02 00  $\frac{1}{4}$   
 37 151 Or 11 times 13  
 4 2228 00 11  $\frac{1}{4}$   
 151 The Product as before,  
 50

But if the Numerator of the Fraction be a large Number, work according to the first Directions.  
 If instead of a contract Number, there had been proposed an abstract one, the Work might have been performed by this Section, or as the 3d Section of the 2d Chapter.

## 44 To value fractional Parts

### SECTION III.

To find of what Whole any proposed CONTRACT NUMBER is any proposed Part or Parts.

#### The RULE.

Imagine the Numerator of the Fraction changed into its Denominator, and the Denominator into its Numerator, and then work as in the last Section.

C. wt. qrs. lb. oz.

What is 03 02 05 13  $\frac{1}{4}$  the  $\frac{1}{4}$  of

C. wt. qrs. lb. oz.

03 02 04 13  $\frac{1}{4}$

24 Or 6 times 4

---

21 01 07 00 C. wt. qrs.

11) 85 01 00 00 (7 3 The

8

4

---

33

..

(Answer.

### SECTION IV.

To find what Part or Parts any CONTRACT NUMBER is of any other of the same kind.

#### The RULE.

**R**educe them both to the least Name found in either of the two, and then make the former the Numerator, and the latter the Denominator

# Of Contract Numbers. 57

minator of a Fraction, which reduce to its least Name ; and it shall show what Part or Parts the former is of the latter.

Ex. 1. What Part or Parts is 3 Cwt. 3 qrs. 16 lb. of 7 Cwt. 3 qrs. ?

Cwt. qrs. lb. oz.	C. qrs.
3 02 05 13 $\frac{1}{2}$	7 3
4	4
<u>14</u>	<u>31</u>
28	28
<u>117</u>	<u>248</u>
28	62
<u>397</u>	<u>868</u>
16	16
<u>2395</u>	<u>5208</u>
397	868
<u>6364</u>	<u>13888</u>
3	3
<u>19096</u>	<u>41664</u>

41664 2  
19096 5  
3472 2  
1736  
.....  
1736 ) 19096  
41664  
4944

(19) The Answer,

1736

SECTION II.

To extract the Root of a Fraction.

The RULE.

**F**irst reduce mixed Numbers to improper Fractions, Compound ones to single ones, and the Fraction to its least Terms; then extract the Root of both Numerator and Denominator, and the Fraction formed by those Roots is the Root sought.

*Example 1.* Extract the square Root of  $\frac{28}{9}$ .

$$\begin{array}{r} 63 \overline{) 28} \\ 28 \\ \hline 7 \end{array}$$

$7) \frac{28}{9} (\frac{4}{3}$  but the Root of 4 is 2, and the Root of 9 is 3; therefore the square Root of  $\frac{28}{9}$  or its equal  $\frac{4}{3}$ , is  $\frac{2}{3}$ .

Extract the Square Root of  $58\frac{1}{2}$ .

This reduced is  $\frac{117}{2}$ , whose Square Root is  $\frac{108}{2}$ , equal to  $7\frac{1}{2}$  the Answer.

I have omitted the Extraction, supposing the Reader already acquainted with the Extraction of the Roots of Integers; and because it comes not within the Scope of my Design.

If the Numerator and Denominator, when reduced to the least Terms, have not both the Root required, the Fraction cannot have that Root extracted: How to approach such Roots, you may see at the 14th Chapter, after it is reduced to a Decimal.



The Operation may be otherwise performed. For if either of the Terms be raised to the Power less by one, than is denoted by the Root, and then multiplied by the other Term, and then you extract out of that Product, the Root required of the Fraction; if this Root placed instead of that Term, which was multiplied into the Power of the other, forms the required Root of the given Fraction.

Example 1, What is the Cube Root of  $\frac{1}{27}$ ?

$$\begin{array}{r} 16 \\ 16 \\ \hline 96 \\ 16 \\ \hline 256 \\ 54 \\ \hline 1024 \\ 1280 \\ \hline 13824 \end{array}$$

Whose Cube Root is 24, and therefore the required Root of the Fraction, given is  $\frac{1}{27}$  equal to  $\frac{1}{3}$  if reduced to its lowest Name. Or thus,

$$\begin{array}{r} 44 \\ 348 \\ \hline 216 \\ 270 \\ \hline 3916 \\ 16 \\ \hline 17496 \\ 2916 \\ \hline 46656 \end{array}$$

Whose Root is 36, and therefore the required Root of the Fraction is  $\frac{1}{27}$  equal to  $\frac{1}{3}$ , as before.

Ex. 3. What is the Square Root of  $\frac{28}{3}$ ?

28

63

84

168

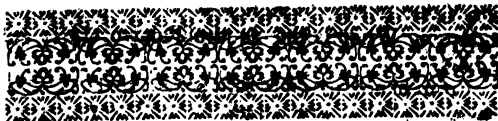
1764

Whole Square Root is 42, and therefore the Square Root of  $\frac{28}{3}$  is  $\frac{42}{3}$ , equal to  $\frac{14}{1}$ .  
Or it is  $\frac{28}{3}$ , equal to  $\frac{14}{1}$ .

From whence it appears, that the Square Root of the Product of the Terms placed instead of either of those Terms, gives the Square Root of the Fraction proposed.

But lastly, observe, that if the required Root cannot be exactly had in such Product, the Fraction is a surd, and hath not the Root required.





## CHAP. VIII.

*Notation. Definitions. Theorems.*



### SECT. I.

#### NOTATION.



**I**N the first Section of the first Chapter, at the 11th Definition, a decimal Fraction was defined to be such a one, as had for its Denominator only an Unit prefixed to Cyphers: But if to the Numerator there be always prefixed so many Cyphers, that the Multitude of the Places in the Numerator be equal to the Multitude of Cyphers in the Denominator, then the Denominator will be always known; and therefore in the Notation is omitted, and the Numerator is written as a whole Number, only for Distinction, there is prefixed to it this Mark ( $\cdot$ ); And so  $\frac{45}{100}$ ,  $27\frac{137}{1000}$ ,  $\frac{4}{1000}$ ,  $24\frac{21}{1000}$ , are written,  $\cdot 45$ ;  $27,137$ ;  $\cdot 004$ ;  $24,21$ ; And by  $\cdot 21$ ;  $\cdot 125$ ;  $\cdot 008$ ;  $9,012$  is to be understood  $\frac{21}{100}$ ,  $\frac{125}{1000}$ ,  $\frac{8}{10000}$ ,  $9\frac{12}{1000}$ . And by  $\cdot 1$ ;  $\cdot 01$ ;  $\cdot 001$ ;  $\cdot 0001$ , &c. is to be understood

derstood  $\frac{1}{10}$ ,  $\frac{1}{100}$ ,  $\frac{1}{1000}$ ,  $\frac{1}{10000}$ , &c. That is the Value of the Places below Unity, decrease in a decuple Proportion, as those above Unity increase.

From hence therefore it appears, that  $\frac{1}{10}$ ,  $\frac{1}{100}$ ,  $\frac{1}{1000}$ ,  $\frac{1}{10000}$ , are equal to  $\frac{1}{10}$ ,  $\frac{1}{100}$ ,  $\frac{1}{1000}$ ,  $\frac{1}{10000}$ ; and these equal to  $\frac{1}{10}$ ,  $\frac{1}{100}$ ,  $\frac{1}{1000}$ ,  $\frac{1}{10000}$  and  $\frac{1}{10}$  and  $\frac{1}{1000}$ ,  $\frac{1}{100}$  and  $\frac{1}{10000}$  and  $\frac{1}{10000}$ .

And consequently a Decimal may be read, by giving each place its due Denomination, or by reading it as a whole Number, and giving it the Name of the last place.

But the Notation of Decimals will appear from the Notation of Integers; for if the Mark of Distinction be placed to the Right hand of Unity, and then Figures continued, the first of these must be the tenth Part of what it would have been if it stood in the next place to the Left-hand (that of Unity) by the Value of Places, and so the first place below Unity gives Tenths, and are usually called Primes.

And a Figure in the second place below Unity, is but a tenth Part of what it would have been, if it stood in the first below Unity, for the same Reason; and so the second place below Unity gives Tenths of Tenths, or Hundredths, and are usually called Seconds. And so the rest as in the following Table.

The

## The Notation TABLE

∞	Tens of Millions.
6	Millions.
7	Hundreds of Thousands.
7	Tens of Thousands.
3	Thousands.
4	Hundreds.
∞	Tens.
2	Units.
7	Primes, or Tenth Parts.
3	Seconds, or Hundredth Parts.
3	Thirds, or Thousandth Parts.
7	Fourths, or ten Thousandth Parts.
3	Fifths, or hundred Thousandth Parts.
7	Sixths, or Millionth Parts.
7	Sevenths, or ten Millionth Parts, &c.

## SECTION II

### DEFINITIONS

24. **A** Terminate Decimal is that which runs downwards to a certain place, and there ends.

25. An Interminate Decimal is that which runs downwards continually, and no where ends.

So 476.5327 is terminate, but 17.4743 4743-4743 and so on continually, is interminate.

26. A compleat Decimal is either Terminate, or such an Intermittent as hath the same Figure or Figures continually Circulating; as 317.45 316 316 316 316, and so continually.

27. An approximate Decimal is such, that hath some places true, but all the following ones uncertain.

So 327.645 + is called 327.645 more something, and 21.5136 - is called 21.5136 less something, or which is the same thing, it is more than 21.5135, but less than 21.5136.

28. The Figure or Figures continually circulating, may be called a Repetend.

29. If one Figure only should be continually annexed, call it a single Repetend.

30. If more than one Figure continually circulate, call it a compound Repetend.

31. Like Repetends are such as consist of an equal Number of places.

32. Repetends that begin at the same place, whether at Units, Primes, Seconds, &c. and end at the same place, whether at fifths, sixths, &c. are called contemporaneous.

34. Duodecimals are such places of Figures below Unity that decrease in a twelfth Rate: And are called Primes, Seconds, Thirds, &c. and are marked by Dashes, thus, 4176 7' 11'' 7''', &c. that is 4176 Integers, 7 Primes, 11 Seconds, 7 Thirds.

35. Sexagesimals are such places of Figures below Unity, that decrease in a sixth rate; and are marked and distinguished as in the foregoing.

SECT,

## S E C T. III.

## THEOREM

11. **I**F the Mark of Distinction in any mix'd or Fractional Expression be moved one place towards the Left-hand, then every Figure, and consequently the whole Expression, is but a tenth Part of what it was before.

12. But if it had been moved towards the Right-hand, then every Digit, and so the whole, would have been ten times as much as it was before.

13. Cyphers to the Right-hand of Decimals, neither encrease nor diminish the Value of the Expression.

14. But Cyphers put between the separating Point and the Figures of a Decimal, diminish the Value of the Decimal.

15. Instead of .9999 and so on continually, put an Unit, for that is either equal to this, or else wants of it less than any thing assignable.

16. Any one of the Figures constituting a compound Repetend may be made the first thereof; for as in  $4.231751751751$ , &c.  $1751$  is the Repetend after  $4.23$ ; so in  $4.231751751751$ , &c.  $751$  is the Repetend after  $4.231$ .

17. Hence any two or more Repetends may be made to begin at the same place; for the Repetends of  $4.231751$ , &c. and  $17.42565656$  will begin at the same place, if the former begin at the thirds, and so its Repetend is  $523$ , after  $4.23$ , and that of the latter  $56$  after  $17.42$ .

18. And any two or more Repetends may be made also to end together, and so to become continuous, if they are continued so many places, that with the place where they begin together, the

the Number of them be the first common Multiple of the Numbers of each single Repetend : For the Number of places in 523 the Repetend after 4.23 (as in the foregoing) is 3, and the Number of places in 56 the Repetend after 17.42 is 2, but the least common Multiple of these is 6; therefore by continuing them 6 places below that where they begin together, they will be 4.23 5 23 5 23, &c. and 17.42 56 56 56, &c. that is conterminous; because after 4.23 the Repetend is 523523, and after 17.42 the Repetend is 565656.

19. Every Terminate may be consider'd as Interminate, by making Cyphers the Repetend.

20. In all results, if the Repetend consists of all Nines, reject them, and make the next superiour place an Unit more.

21. In all Results, if the Repetend consists of some other Repetend of fewer places, retain the latter only.

22. In all circulating Expressions dash the first and last of the Repetend, omitting the consequent places.

23. If a Divisor prime to its Dividend be 2 or 5, or any Power of either of them, or composed of any Powers of them, the Quotient will be Terminate: And the Cyphers to be annexed to the Dividend shall be as many as there are Units in the Index of the highest Power.

24. If a prime Divisor, no aliquot Part of the Dividend, be neither 2 nor 5, the Quotient shall be interminate; and the Cyphers to be annexed to the Dividend, in order to compleat the Repetend in the Quotient, shall be as many as the least Number of Nines written one after another, that is a Multiple of the Divisor, and that is the Number of the Places in the Repetend, which shall always be as many as the Units in the Divisor,



visor, wanting one, or some aliquot part of the same.

25. The like is also true of Divisors composed of Primes, neither 2 nor 5, if Prime to the Dividend.

26. If a Prime  $b$ , neither 2 nor 5, divide a Dividend no Multiple of  $b$ , and form in the Quotient a Repetend consisting of  $c$  Places; and also some Prime  $d$ , neither 2 nor 5, divide a Dividend, no Multiple of  $d$ , and form in the Quotient a Repetend consisting of  $f$  Places, then the Product of  $b$  and  $d$  dividing a Dividend Prime to it, shall form a Repetend consisting of as many Places as the Units in the least common Multiple of  $c$  and  $f$ .

27. If the Power of some Prime  $b$ , neither 2 nor 5, dividing a Dividend Prime to it, form in the Quotient a Repetend of some Number of places  $c$ ; then the next superiour Power of the same Prime  $b$  dividing a Dividend Prime to it, forms a Repetend of a Number of Places expressed by  $b$  times  $c$ ; except when  $b$  is 3, and the Index of its Power 1.

28. Any integral Divisor prime to its integral Dividend given to find how many places the Repetend in the Quote consists of; If the Divisor have Cyphers in the right hand places, omit them; then it even divide by two as oft as possible; but if its right-hand place be 5, divide by 5 as oft as possible; and lastly, divide Nines written one after another by the last Result till nothing remain; and the Number of Nines used shall shew the Number of Places in the Repetend. But note, that in dividing the first proposed Dividend by its Divisor, the Repetend shall begin after so many places in the Decimals are past, as the Cyphers cut off, and the Number of the Two's or Five's divided by.

## 66 *Addition of Terminates.*

29. If any Repetend once written as terminate be made the Numerator of a Vulgar Fraction, and its Denominator consists of as many places of Nines as the places of the Repetend, that Vulgar Fraction shall be equal to the Repetend, if written after the terminate part of the Expression.

30. If any required Root of some terminate Number be not exactly had from the Places given, it cannot be exactly had.

31. If any required Root of some circulating Expression doth not repeat from the Repetend once used, it cannot repeat at all.



## CHAP. IX.

### *Addition of DECIMALS.*



#### S E C T. I.

#### *Addition of T E R M I N A T E S.*

#### The RULE.



**P**LACE like Places under like Places, imagine all Voids supplied with Cyphers, and then add as in Integers.

Add 476.2145 .903 .4.17634  
.00476325 3.146 together.

# Addition of Interminates, 67

$$\begin{array}{r}
 467.2145 \\
 .903 \\
 4.17634 \\
 .00476325 \\
 3.146 \\
 \hline
 484.44460325 \quad \text{The Answer,}
 \end{array}$$

## S E C T. II.

*To add INTERMINATES that have single Repetends.*

The R U L E.

**M**AKE all conterminous, and then add as in the foregoing Section, only to the right-hand Column, add as many Units as there are Nines in it. And the Digit subscribed to that Column shall be a Repetend.

$$\begin{array}{r}
 \text{Add } 2.\dot{3} \quad 2.\dot{7} \quad 4.\dot{7}\dot{6} \quad \dot{3} \quad 2.\dot{3}\dot{3} \\
 5.8 \text{ and } 4.7\dot{3} \text{ together} \quad 2.\dot{7}\dot{7} \\
 \quad \quad \quad \quad \quad 4.\dot{7}\dot{6} \\
 \quad \quad \quad \quad \quad \dot{3}\dot{3} \\
 \quad \quad \quad \quad \quad 5.80 \\
 \quad \quad \quad \quad \quad \underline{4.\dot{7}\dot{3}}
 \end{array}$$

The Answer. 20.74

$$\begin{array}{r}
 47.244 \\
 2.888 \\
 37.855 \\
 3.777 \\
 38.473 \\
 48.76, \\
 24.85. \\
 \hline
 203.550
 \end{array}
 \quad
 \begin{array}{r}
 2.76666 \\
 3.18555 \\
 14.33333 \\
 21.7684. \\
 7.36666 \\
 24.88888 \\
 \hline
 74.27954
 \end{array}$$

# 68 Addition of Interminates.

1769675	
.0020833	
358.8833333	
.003125.	7.644
9764.9918666	2.838
.0010418	2.718
493.5958333	6.377
.9020833	.648
<hr/> 12387.1541866	<hr/> 20.222

## S E C T. III.

To add INTERMINATES that have compound Repetends.

The R U L E.

**M**AKE all conterminous, and then add as in the first Section, only to the right-hand Column add as many Units as there are Tens in that Column where the Repetends all begin together ; And then the Figures subscribed to the aforesaid Columns shall be the first and last of the Repetend.

34.7621621	8.5935882	3.0459
15.341414	2.9417853	.2763
<hr/> 4.2450641	<hr/> 11.5353535	<hr/> 3.2222
54.2213677	2.2164	3.117.087087
	3.1483	623.541741
3.422127	62.9262	124.708348
2.1414141	314.8314	6.235417
<hr/> 6.5458722	<hr/> 382.9204	<hr/> 3871.572894
12.0999999		
that is 12.1,		

# *Addition of Approximates.* 69

$$\begin{array}{r}
 37.42182 \\
 2.15 \\
 7.42222 \\
 \hline
 47.00404
 \end{array}
 \qquad
 \begin{array}{r}
 4.12422432 \\
 7.32212121 \\
 6.45 \\
 \hline
 17.92644553
 \end{array}$$

## SECT. IV.

### *To add APPROXIMATES.*

#### The RULE,

**P**lace and work as in the first Section :  
 Only observe that the certain Places of the  
 Decimal are for the most part fewer by one than  
 the decimal Places in any one of the Approximates  
 given.

12.34518—

10.5

.28

3.45455—

1.41421†

1.25928†

29.2532 Certain.

This Rule is such, that we shall scarce ever err  
 more than Unity in the last Place ; but by two  
 Operations, one made with more than just, the  
 other made with less than just, we shall always  
 be able to judge how far is certain, viz. as far as  
 they agree.

12.34518

10.5

.28

3.45455

1.41422

1.25929

29.25324

12.34517

10.5

.28

3.45454

1.41421

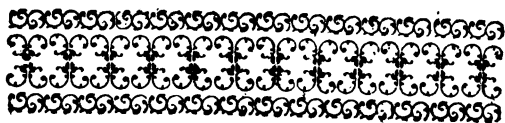
1.25928

29.25320

Therefore

## 70 *Subtraction of Terminates.*

Therefore because they agree to four Places in the Decimals, so many are certain, as in the first Operation.



## CHAP. X.

### *Subtraction of Decimals.*



#### S E C T. I.

*To Subtract* T E R M I N A T E S,

The R U L E,



**P** L A C E as in Addition, and imagine Voids supplied with Cyphers, and subtract as in Integers. )

$483.525$	$217.45$	$314$
$\underline{47.178}$	$\underline{184.9}$	$\underline{211.435}$
$436.347$	$32.55$	$102.565$

$$\begin{array}{r} 217.5 \\ 116.875 \\ \hline 100.625 \end{array}$$

S E C T,

# Subtraction of Interminates. 71

## S E C T. II.

*To subtract INTERMINATES that have single Repetends.*

The RULE.

**P**LACE and continue as in Addition, and subtract as in the first Section; only when the Repetend of the Subtrahend is greater than the Repetend of the Minuend, encrease the latter by 9, then subtract, and carry one to the next place.

27.64333	56.238	24.700	12.76480
<u>12.76460</u>	<u>12.200</u>	<u>12.273</u>	<u>2.33333</u>
14 87873	44.038	12.426	10 43146
2.470	14.76438	23.43	243.333
<u>.243</u>	<u>8.58555</u>	<u>14.77</u>	<u>125.274</u>
2.226	6.20883	8.68	118.058

## S E C T. III.

*To subtract INTERMINATES that have compound Repetends.*

The RULE.

**P**repare as in Addition, and subtract as in Integers; but if you borrow one, in subtracting the place where both Repetends begin, add one

## 72 Subtraction of Approximates.

one to the Right-hand place of the Subtrahend.  
The Repetend in the Answer, is as in Addition.

$$\begin{array}{r} 48.7327327 \\ 1.5271717 \\ \hline 47.2055610 \end{array} \quad \begin{array}{r} 31.71287 \\ 8.42272 \\ \hline 23.29015 \end{array} \quad \begin{array}{r} 13.9778960 \\ 8.7647647 \\ \hline 5.2131313 \end{array}$$

$$\begin{array}{r} 78.5222 \\ 3.7647 \\ \hline 74.7575 \end{array} \quad \begin{array}{r} 48.7652000 \\ 23.8548548 \\ \hline 24.9103452 \end{array}$$

## S E C T. IV.

To subtract APPROXIMATES.

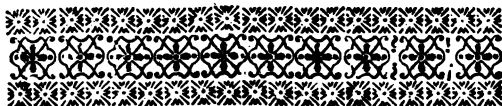
The RULE.

**P**LACE as in Addition, and subtract as in the 1<sup>st</sup>. Section; and so the last place shall never err more than an Unit, if both are made more than just, or both less than just.

$$\begin{array}{r} 10.5 \\ 3.45455+ \\ \hline 7.04545 \end{array} \quad \begin{array}{r} 84.3275+ \\ 2.1847+ \\ \hline 82.1428 \end{array}$$

CHAP.





## CHAP. XI.

### *Multiplication of Decimals.*



#### SECT. I.

*To multiply* TERMINATES.

#### THE RULE.



**P**LA CE and multiply as in Integers, and then from the Product to the Right-hand, cut off as many places for Fractions as there are fractional places in both Factors; but if it happen that there are not so many, supply the Defect by Cyphers to the Left-hand.

$$\begin{array}{r}
 74.125 \\
 671.3 \\
 \hline
 222375 \\
 74125 \\
 518875 \\
 \hline
 444750 \\
 49760.1125
 \end{array}$$

$$\begin{array}{r}
 4.2346 \\
 .00125 \\
 \hline
 211730 \\
 84692 \\
 42346 \\
 \hline
 .005293250
 \end{array}$$

$$\begin{array}{r}
 .4251 \\
 .241 \\
 \hline
 4251 \\
 17004 \\
 8502 \\
 \hline
 .1024491
 \end{array}$$

L

SECT.

## S E C T. II.

*To multiply INTERMINATES with single Repetends.*

## The RULE.

**I**F the Multiplicand be Interminate, and the Multiplier a single Digit, multiply as in the foregoing Section, only to the last place of the Product, add as many Units as it contains Nines, and that place shall be a Repetend: But if the Multiplier be a Repetend, multiply by it as tho' it were a terminate Digit, placing the Product one place forwarder than ordinary towards the Left-hand; and divide the Result by 9, continuing the Quotient, till you arrive at a single or a compound Repetend; then beginning at the place under the last of the Multiplicand, cut off for Fractions, as taught in the first Section of this Chapter.

But if the multiplying Repetend be 3, imagine the Multiplicand carried one place towards the Left-hand, and then  $\frac{1}{3}$  part of it, cutting off as before, shall be the Answer.

*Lastly*, If the Multiplier consists of many places, multiply by each place thereof, as taught above, and add the particular Products together, cutting off Fractions as above.

$$\begin{array}{r}
 48.7\bar{8} \\
 \underline{\phantom{00}4} \\
 195.0\bar{2}
 \end{array}
 \qquad
 \begin{array}{r}
 3.17\bar{6} \\
 \underline{\phantom{00}3} \\
 .953\bar{0}
 \end{array}
 \qquad
 \begin{array}{r}
 845.\bar{3} \\
 \underline{\phantom{00}.07} \\
 59.17\bar{8}
 \end{array}$$

with single Repetenda. 75

$$\begin{array}{r} 48.734 \\ .04 \\ \hline 9) 194936 \\ 2.16598 \end{array} \quad \begin{array}{r} 67.643 \\ .06 \\ \hline 9) 405862 \\ 450985 \end{array}$$

$$\begin{array}{r} 26.45 \\ .004 \\ \hline 9) 10582 \\ 11788024.6913 \end{array}$$

$$\begin{array}{r} 47.32 \\ 0.03 \\ \hline 15773 \end{array} \quad \begin{array}{r} 584.26 \\ .3 \\ \hline 194.785 \end{array} \quad \begin{array}{r} 721.48 \\ .03 \\ \hline 2404851 \end{array}$$

$$\begin{array}{r} 748.64 \\ .0634 \\ \hline 299457 \\ 2245933 \\ 44918866 \\ 47463057 \end{array} \quad \begin{array}{r} 487.65 \\ 2.174 \\ \hline 9) 195060 \\ 216733 \\ 341355 \\ 48765 \\ 97530 \\ 1069.36783 \end{array}$$

$$\begin{array}{r} 1276.47 \\ 4.13 \\ \hline 425490 \\ 127647 \\ 110588 \\ 5276.0760 \\ 1.2 \end{array}$$

## 76 To multiply Interminates

$$\begin{array}{r}
 23 \\
 56 \\
 \hline
 9) 140 \\
 \underline{185} \\
 1186 \\
 \underline{1322}
 \end{array}
 \qquad
 \begin{array}{r}
 1x \\
 1x \\
 \hline
 9) 1x \\
 \underline{x23456790} \\
 1x11111111 \\
 \underline{1.23456790x}
 \end{array}$$

$$\begin{array}{r}
 48.754 \\
 2.13 \\
 \hline
 1625x48 \\
 4875444 \\
 97508888 \\
 \hline
 10400948x
 \end{array}$$

$$\begin{array}{r}
 3.47 \\
 2.4 \\
 \hline
 9) 139x \\
 \underline{15456790123} \\
 69855555555 \\
 \hline
 8.5012345679
 \end{array}$$

### S E C T. III.

To multiply INTERMINATES that have Compound Repetends.

#### The RULES.

**I**F the Multiplicand be Interminate, and the Multiplier a single Digit; multiply as in the first Section of this Chapter; only add to the Right.

*that have compound Repetends. 77*

Right-hand place of the Product as many Units as there are Tens in that place which is formed by the Left-hand place of the Repetend : And the Repetend of the Product consists of places not more than the Repetend of the Multiplicand.

$$\begin{array}{r} 58.7845 \\ \hline 411.3819 \end{array} \quad \begin{array}{r} 2184.6732 \\ \hline 109.233662 \end{array}$$

But if the Multiplier consists of many places, multiply by each place as in the foregoing, and then add as taught in the 3d Section of the 9th Chapter.

$$\begin{array}{r} 417.6328 \\ 76.45 \\ \hline 20881828 \\ 167053023 \\ 2505795295 \\ 29234277277 \\ \hline 31928.007212 \end{array}$$

$$\begin{array}{r} 8.6714285 \\ 1.19 \\ \hline 780428572 \\ 867142857 \\ 8671428571 \\ \hline 10.318999999 \\ \text{that is } 10.319 \end{array}$$

# 78 To multiply Interminates

$$\begin{array}{r}
 2.747420x \\
 \underline{7.03} \\
 82422604 \\
 19231941031 \\
 \hline
 19314363636 \\
 \text{that is } 19.31436
 \end{array}$$

$$\begin{array}{r}
 1.4086419753 \\
 \underline{80.1} \\
 14086419753 \\
 11289135802469 \\
 \hline
 11283222222222 \\
 \text{that is } 112.832
 \end{array}$$

But if the Multiplier be Interminate, imagine the separating Point of it moved toward the Left-hand, as many places as its Repetend consists of, and then place it under the Multiplier given, and subtract; and multiply the Multiplicand by the Remainder, as taught above.

Secondly, add the highest Figure in the Result to that which is as many places below it, as the Repetend of the Multiplier consisted of places; and then that next below the former to that next below the latter; and so on till you come to the lowest place, if the Multiplicand be terminate; and the undermost Figures shall be the Product, whose Repetend shall be like that of the Multiplier. But if both Factors be interminate, then go on till you arrive at a Repetend, or a sufficient degree of Exactness. But if by adding any Figure to some other below it, the added Figure is in-

# that have compound Repetends. 79

increased; or if that to which it is added, and all the Figures between it and the Figure added, be Nines; then in either Case, the place to which there was added shall be one more.

The carefull Observance of the following Examples will sufficiently explain the Rule.

$$\begin{array}{r} 48.76 \\ .1348 \\ .0001 \\ \hline 1344 \end{array}$$

$$19504$$

$$19504$$

$$14628$$

$$4876$$

$$\begin{array}{r} 6.553344 \\ 6 \\ \hline \end{array}$$

$$6.559344$$

$$5$$

$$6.559844$$

$$5$$

$$6.559894$$

$$9$$

$$6.559903$$

This Example is here wrought at large, the better to inform the Reader; but the same may most conveniently stand thus, where all the added Figures are mentally added;

$$48.76$$

$$.1348$$

$$.0001$$

$$\hline .1344$$

$$19504$$

$$19504$$

$$14628$$

$$4876$$

$$\hline 6.553344$$

$$9893$$

$$90$$

$$6.559903$$

If the Multiplier be a Repetend only, without any terminate part; there is nothing to be subtracted.

# 80 To multiply Intermittates

$$\begin{array}{r}
 417.64 \\
 \underline{4217} \\
 292348 \\
 41764 \\
 83528 \\
 \underline{167056} \\
 1761.18788 \\
 \underline{25391} \\
 3640 \\
 \underline{1761.3640x}
 \end{array}
 \begin{array}{r}
 1433.531 \\
 \underline{x.71990} \\
 129017790 \\
 12991779 \\
 1433531 \\
 10034717 \\
 \underline{1433531} \\
 2465.52996690 \\
 3132143 \\
 \underline{2432} \\
 2465.53243243
 \end{array}$$

that is 2465.5324

$$\begin{array}{r}
 2203.355 \\
 \underline{28.5714} \\
 8813420 \\
 2203355 \\
 15423485 \\
 11016775 \\
 17626840 \\
 \underline{4406710} \\
 62952.9370470 \\
 3099999 \\
 \underline{00000} \\
 62953.
 \end{array}$$



that have compound Repetends. 81

$$\begin{array}{r}
 4322.105901 \\
 \underline{\phantom{4322.105901} .0288} \\
 21610529505 \\
 34576847298 \\
 4322105901 \\
 \hline
 79.9589591685 \\
 800289870566 \\
 \phantom{79.9589591685} 3 \phantom{00} 9816 \\
 \hline
 80.0389981666
 \end{array}$$

$$\begin{array}{r}
 47253.375 \\
 \underline{\phantom{47253.375} 248} \\
 378027000 \\
 189013500 \\
 47253375 \\
 \hline
 69934.995 \\
 70094999 \\
 \phantom{69934.995} 05000 \\
 \hline
 70005.
 \end{array}$$

# 82 To multiply Intermittent

$$\begin{array}{r}
 3142.1532 \\
 486.513 \\
 \hline
 1486 \\
 \hline
 486027 \\
 \hline
 219950724 \\
 62843064 \\
 1885291920 \\
 251372236 \\
 \hline
 125686128 \\
 \hline
 1527171.2933364 \\
 86998822297 \\
 \hline
 9933 \\
 \hline
 1528699.9933297
 \end{array}$$

$$\begin{array}{r}
 3.145 \\
 4.297 \\
 \hline
 1004 \\
 \hline
 4.293 \\
 \hline
 9436 \\
 283090 \\
 629090 \\
 \hline
 125818.18 \\
 \hline
 13.503436363636 \\
 169422169422.1 \\
 \hline
 533 \quad 533 \\
 \hline
 13.5169533 \\
 \hline
 243.063 \\
 206 \\
 \hline
 3 \\
 \hline
 243.306
 \end{array}$$

*that have compound Repetends. 83*

But if the Repetend of the Product doth not so speedily repeat as might be wished for, proceed to a determined Exactness; as in the following Example, where I have continued the Product to 24 places in Decimals.

$$\begin{array}{r}
 21485214 \\
 4817652 \\
 \hline
 4 \\
 4817648 \\
 \hline
 171882814 \\
 859412572 \\
 1289118888 \\
 150397200200 \\
 214852143143 \\
 17188281451451 \\
 85941257257257 \\
 \hline
 10350868153572772772772772772 \\
 78403340276123949996711668 \\
 \hline
 5445172408227 \\
 \hline
 10350878504451277224049996822768
 \end{array}$$

Lastly, if it be desired to find what is left out; observe that omitting as many of the last places as the Repetend of the Multiplier did consist of, and the Product is 10350878.504451277224049996, which wants of the true Product  $\frac{822768227}{999999}$

of an Unit in the last place, the place of 6 after the 3 Nines.

The Construction of this Fraction is thus; Make the Repetend of the first Product 772 (beginning where the Work ends) the Numerator;

M 2

T 9

## 84 To multiply Intermittent

To which subscribe for a Denominator as many places of Nines; To this prefix as many of the last places in the Answer as the places in the Multiplier's Repetend. Lastly, to this Number subscribe as many places of Nines for a Denominator.

But observe that if the Product be divided into Periods, beginning at the left Hand, each Period to consist of as many places as the Repetend in the Multiplier did; and a Point put over the last place of each Period: Then the whole first Period may be added to the second, and the Result to the third, and so on: But when the Sum of the Periods consists of all Nines, or the added Period be increased an Unit; the last place in such Sum shall be made one more; and so the true Product will be had.

To illustrate this observe the following Operation, which is the foregoing Example.

$$\begin{array}{r|l|l}
 10350868.1535 & 727727 & 727727 \text{ \&c. the last} \\
 103508 & 785043 & 512771 \text{ Product.} \\
 \hline
 785043 & 512770 & 240498 \\
 4 & 1 & 9 \\
 & 2 & 
 \end{array}$$

10350878.5044512772240499, &c. true Prod.

But if the added Figures were omitted, which might be done without any Burthen to the Memory, the Operation would stand thus.

$$\begin{array}{r|l|l}
 10350868.1535 & 727727 & 727727 \text{ \&c. the 1st} \\
 785043 & 512770 & 240498 \text{ Product.} \\
 4 & 1 & 9
 \end{array}$$

10350878.5044512772240499, &c. true Prod.  
Hence

## that have compound Repetends. &c

Hence it appears that from the first Product the true one may be obtained in one single Line, if we know how the last Figure of each Period should be increased. In order to discover which, add the first Figure of the Period then to be added to the first Figures of the two succeeding Periods, and increase their Sum by the Carries from the Sum of the second Figures of the same Periods; and the Number of Tens herein contained, call the Carries from the three Figures.

Then in adding the first Period to the Second, increase the last Place by the Carries from the 3 Figures.

But in adding any other Period to its following, when  $\begin{Bmatrix} 0 \\ 1 \end{Bmatrix}$  was carried to the last Period, if the three Figures make  $\begin{Bmatrix} 10 \\ \text{not } 20 \end{Bmatrix}$  increase the last place by  $\begin{Bmatrix} 1 \\ 0 \end{Bmatrix}$ .

So in the foregoing Example, because the Sum of 1, 6, 7 the first Figures make 14, which carries 1; instead of adding 103508 the first Period to the Second, I add 103509 the First Period increased by 1; and then the Work stands thus;

$$\begin{array}{r} 10350868153572772772727, \text{ \&c.} \\ 785044 \end{array}$$

Secondly, because 7, 7, 7 make 21, and 1 was carried to the last Period; instead of adding 785044, I add 785045, and then the Work stands thus;

$$\begin{array}{r} 10350868153572772772727, \text{ \&c.} \\ 785044512772 \end{array}$$

Thirdly, because 5, 7, 7, with 0 the Carry of the Seconds, make but 19 not 20; and 1 was carried to the last place; I don't increase the Period

## 86 Multiplication of Approximates.

riod 512772 at all, but add it without Increase, and then the Work stands thus ;

10350868153572772772727, &c.

785044512772240499, &c.

Lastly, if the Left-hand Figures of the first Product be brought down to the undermost Line, the Work will stand thus ;

10350868153572772772727, &c. first Product.

103508785044512772240499, &c. true Product,

## SECT. IV.

To multiply APPROXIMATES.

The RULE.

**W**ORK as in the first Section of this Chapter ; but if both Factors are Approximates, the uncertain places of the Product shall be one more than the places in the longest Factor ; but if one is compleat, the uncertain places shall be one more than the places in the compleat Factor.

415763+

5065656392

1683852

3326104

415763

831526

415763

5065656392

But all the places below 50.6 are uncertain, by the Rule.

3324312

1452+

6248624

15621560

12497248

3124312

4536501024

But all the places below 45. are uncertain, by the Rule.

## Multiplication of Approximates. 87

$$\begin{array}{r}
 48.1764+ \\
 \times 2.16 \\
 \hline
 2890590 \\
 481765 \\
 963530 \\
 \hline
 104.061240
 \end{array}$$

But all the places below 104.06 are uncertain, by the Rule.

But most of the Figures in the foregoing Examples of this Section are useless : Therefore, by the following Rule the useless places may be saved.

Having, according to the Rule, discovered how many decimal places will be in the Product, and also how many places will be uncertain ; you may find the place of the Left-hand uncertain Figure ; under which put the Units place of the Multiplier, and invert the Order of all the other places of it. Then in multiplying, begin at that Figure of the Multiplicand which stands over the Figure wherewith you are then multiplying, setting down the first Figure of each particular Product directly underneath one another ; yet herein you must have a due regard to the Increase which would arise out of the Figures to the Right hand of that Figure in the Multiplicand you then begin with ; and in the Product the last place is uncertain.

To exemplify this, see the two first Examples worked over again.

## 82 Multiplication of Approximates.

$$\begin{array}{r} 415.763 \\ \times 48121.0 \\ \hline \end{array}$$
 Multiplier inverted.

$$\begin{array}{r} 4157631 \\ \times 48121 \\ \hline \end{array}$$
 Tens in 4 by 4... 1

$$2063 \text{ but certain } 505$$

$$\begin{array}{r} 3124312 \\ \times 25410.0 \\ \hline \end{array}$$

$$312 \dots 312 \text{ by } 1$$

$$3124 \dots 31 \text{ by } 4$$

$$15 \dots 3 \text{ by } 2$$

$$45,1 \text{ but } 45 \text{ only certain.}$$

In the first of these Examples, the Fractions in both Factors are 8, and so many are the Decimal places in the Product; but the uncertain places are 7 by the Rule: Therefore the Left-hand uncertain place is the second, in Decimals, under which I set the Units place of the Multiplier, and invert the Order of the rest, and then multiply, as in the Example.

But when the Factors are both compleat, you may secure what place you please, by this Rule.

But the safest Way of securing all the certain places in a Product from Approximates; is by making a double Operation, viz. the one with more than just the Approximate Factors, the other with less; for then as far as these two Products agree, is certain.

And so the two first Examples of this Section will be thus.



# Multiplication of Approximates. 89

$$\begin{array}{r}
 415.763+ \\
 12183+ \\
 \hline
 1247289 \\
 3326104 \\
 415763 \\
 831526 \\
 415763 \\
 \hline
 5065240629
 \end{array}$$

$$\begin{array}{r}
 415.764- \\
 12184- \\
 \hline
 1663056 \\
 3326112 \\
 415764 \\
 831528 \\
 415764 \\
 \hline
 5065668576
 \end{array}$$

Whence it appears that 50.65 is certain, but no farther.

$$\begin{array}{r}
 3124312 \\
 .01452+ \\
 \hline
 8248624 \\
 15621560 \\
 12497248 \\
 3124312 \\
 \hline
 45.36501024
 \end{array}$$

$$\begin{array}{r}
 3124312 \\
 .01452- \\
 \hline
 9372936 \\
 15621560 \\
 12497248 \\
 3124312 \\
 \hline
 45.39625336
 \end{array}$$

And so it appears that 45.3 is certain, but no farther.

So here it may be observ'd, that by this double Operation, we are certain of a Place more than by the former Rule; which will happen also in many other Examples.



# Division of Decimals, &c. 91

be a Remainder, imagine Cyphers as many as you please annexed to the Dividend in the class places, which bring down, and divide in Division till you come to no Remainder, or a Repetend, or a sufficient Degree of Exactness.

25.6) 74376 (1290

1358

11840

1120

960

1010

1120

Here the Decimals in the Dividend with the Cyphers annex'd are eleven ; but in the Divisor only one : Therefore there are ten places of Decimals in the Quotient.

Divide 481736 by 0.87 till you have ten Places of Decimals in the Quotient.

21877481736

481736

15860

5870

5870

222450

20630

9470

7220

0000

Divide  
N 2

of Division by 164, 7264, by 11, and still there re-  
mains nothing; or till you find the Figure re-  
peated.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

In this Example because there remain'd 32  
when there was nothing but Cyphers to be  
brought down; and because the same Remain-  
der 32 at last came again under the same Con-  
ditions; the next Quotient Figure, and also all  
the following will circulate, as is denoted in the  
Quotient by the dash'd Figures.

The several Varieties of valuing the Quote  
will clearly appear by the following Examples,  
where the Operations are omitted, because, ac-  
cording to the Rule, they are performed as in  
Integers.

4217) 176118788(41764  
42.17) 176118788(4176400  
4217) 176118788(4176400000  
42.17) 176118788(417640  
4217) 176118788(41764  
42.17) 176118788(41764  
4217) 176118788(41764  
42.17) 176118788(41764  
4217) 176118788(41764

There

There is another very excellent Method for valuing the Quotient besides the foregoing; Thus,

Consider the Value of that Place in the Dividend under which the Units Place of the Divisor falls, in asking the first Question; for the same Value shall the first Figure in the Quotient always be of.

So, in the sixth of those Examples, where the Operations are omitted; the 2 in the Units Place of the Divisor falls under 6 the Units Place of the Dividend; therefore the first Place in the Quote gives Units.

In the last; the 4 in the Units Place of the Divisor falls under the 7 in the second place of Decimals of the Dividend; therefore the first significant Figure of the Quotient is in the second place of Decimals.

If the Divisor at any time consist of Figures with Cyphers annexed, such Cyphers may be omitted in the Operation, provided they be accounted for in valuing the Quotient.

$$\begin{array}{r}
 24000 \overline{) 17648} \\
 \underline{48} \phantom{000} \\
 8000 \phantom{00} \\
 \underline{48} \phantom{00} \\
 3200 \phantom{00} \\
 \underline{48} \phantom{00} \\
 1600 \phantom{00} \\
 \underline{48} \phantom{00} \\
 800 \phantom{00} \\
 \underline{48} \phantom{00} \\
 320 \phantom{00} \\
 \underline{48} \phantom{00} \\
 160 \phantom{00} \\
 \underline{48} \phantom{00} \\
 80 \phantom{00} \\
 \underline{48} \phantom{00} \\
 32 \phantom{00} \\
 \underline{48} \phantom{00} \\
 16 \phantom{00} \\
 \underline{48} \phantom{00} \\
 8 \phantom{00} \\
 \underline{48} \phantom{00} \\
 0
 \end{array}$$

Hence therefore to divide by 10, 100, 1000, &c. is but to move the separating Point 1 2 3, &c. places to the Left hand,

SECT.

# 24 Division of Decimals

## SECTION II To Divide by INTERMINATES with Repetends.

### THE RULE.

Imagine the separating Point of the Divisor moved as many Places to the Left-hand as the Divisor's Repetend consists of Places, and then subtract it from the Divisor it self: And the separating Point of the Dividend moved towards the Left-hand as many Places as that of the Divisor, and then subtracted from the Dividend. Lastly, divide with these Remainders, as taught in the first Section, and the Quotient shall be that sought.

$$\begin{array}{r} 16038.2) 73688.943488(4594 \\ 1603 \phantom{.} \phantom{00} 73688.9434 \end{array}$$

$$\begin{array}{r} 15877.8) 72952.854854 \\ 15877 \phantom{.} \phantom{00} 72952.854854 \\ \underline{944085} \\ 1501954 \\ 729528 \end{array}$$

$$\begin{array}{r} 2174) 106036988(48765 \\ 217 \phantom{.} \phantom{00} 106036988 \end{array}$$

$$\begin{array}{r} 1957) 95433105 \\ 1957 \phantom{.} \phantom{00} 95433105 \\ \underline{17153} \\ 14971 \\ 12720 \end{array}$$

$$\begin{array}{r} 9785 \\ 008 \end{array}$$

*by Interminates with Repetends. 99*

008). 235 876 2469 23 (26.47

0 0235358024692

008).2118243282222(

5. I

38.910.9 327

6.2

417.6328) 31928.007212 (76.45

4176 21928007

417.2149 11896.079105(

2691036L

18774670

20860745

0317) 198272614 (124.67)

0000 394271

.0317)394878341(1

7782257

1447

100-341798-301 (4 of 8)

2193 101 101

2314 70

95401

We are to observe, that in subtracting the Divisor or Dividend diminished from themselves, the Repetends are often omitted, because they are





## Division of Approximates. 97

If 58626 be written immediately after 2222, thus 222258626, and then 2222 subtracted from it, the Remainder 222256404 make Numerator : To the Denominator 4172 annex as many Cyphers as there are Nines in the superiour Denominator, and from that subtract 4172, and the Remainder 217195828 make Denominator, and the Fraction  $\frac{222256404}{217195828}$  shall be equal to the foregoing.

### S E C T. III.

*To divide APPROXIMATES.*

#### THE RULE.

**D**ivide as in the first Section of this Chapter. But to know how many Places in the Quotient are certain; write the Divisor under that part of the Dividend which gives the first Figure in the Quotient; then count how many Places from the Left hand Figure of the Divisor to the first doubtful place (whether in the Divisor or in the Dividend) for one less shall the certain Places of the Quotient be.

$$\begin{array}{r}
 31.45275+ ) 2187654278 - (695536 \\
 \underline{30048927} \\
 17414628 \\
 \underline{168825} \quad 30 \\
 11561550 \\
 \underline{2425} \quad 7250 \\
 2385600
 \end{array}$$

Here we stop, for by the Rule, no more places are certain; and also observe, that what is left out, is therefore uncertain too.

## 98 *Division of Approximates.*

If after the Place in the Divisor, which limits the uncertain places, there be drawn a Line, as in the Example; all the Figures to the Right-hand of it may be omitted; and so the Work would then stand thus.

$$\begin{array}{r}
 31.45275+ ) 21876.54378 - (695.536 \\
 \underline{30048937} \\
 1741462 \\
 \underline{158825} \\
 11561 \\
 \underline{2125} \\
 238
 \end{array}$$

When the highest uncertain place is a Nine, make that to the Left-hand of it, an Unit more, whether it be in Addition, Subtraction, Multiplication, &c.,

But if we make two Operations; viz. The one with a Divisor the nearest, more than just, and a Dividend the nearest, less than just; the other with a Divisor the nearest, less than just, and a Dividend the nearest more than just; then so many places, and no more are certain, as agree in the Quotient.

And so the Example will be thus.

$$\begin{array}{r}
 31.45275+ ) 21876.54378 - (695.5367 \\
 31.45276- ) 21876.54377+ (695.5363
 \end{array}$$

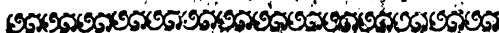
Therefore the Quotient certain is 695.536.

Hence it appears, that it is most sure to use a double Work; but observe that every compleat Decimal in such Operations, needs not be altered to a more or less than just.



## CHAP. XIII.

### *Reduction of Decimals.*



#### S E C T. I.

*To Reduce a Vulgar FRACTION to a DECIMAL.*

#### The RULE,



**D**IVIDE the Numerator by its Denominator, and the Quotient will be the Answer.

*Example I, f*

7)5.

.714285 The Answer.

*Ex. II,*

Example II.  $\frac{1}{3}$ 

91) 53. (682417 The Answer,

750

220

380

160

690

53

Example III.  $\frac{1}{4}$ 

36) 23. (638 The Answer.

140

320

32

Example IV.  $\frac{1}{5}$ 

649) 11. (.0171875 The Answer,

460

120

560

480

320

S E C T.

## S E C T. II.

*To Reduce MONEY, WEIGHT, &c.  
to Decimals.*

### The RULE.

**F**IRST express in a vulgar Fraction, what part or parts of the Integer, the given Money, &c. is, (as taught at *Sett. 2. Ch. 7.* of Part 1.) and then reduce that Fraction to a Decimal, and it will be that sought.

*s. d.*  
Reduce  $4\ 7\ \frac{1}{2}$  to the decimal of a Pound Sterling.

4 7 $\frac{1}{2}$	20	
<u>12</u>	<u>12</u>	
55	240	$\frac{333}{576}$
<u>4</u>	<u>4</u>	
222	960	

960) 222. (.23125

300

120

240

480

...

This is the Substance of the Method usually proposed, to reduce Money, Weight, &c. to a Decimal. But the following one is much readier, and also every whit as easie and as general.

*First*, Reduce the least Denomination to the Decimal part or parts of the next Superiour, to the Right-hand of which prefix all that is given of that next superiour Denomination; *Secondly*, Reduce this mix'd Number to the decimal Part of the next superiour, to which prefix what is given of this last superiour, and so proceed till you arrive at the Decimal of the Integer sought.

Reduce

# 161 Reduction of Decimals

Reduce 7 s. 7 d.  $\frac{1}{2}$  to the decimal Part of a Pound Sterling.

$$\begin{array}{r|l} 4 & 2. \\ 12 & 7.5 \\ 20 & 7.625 \\ & .38125 \end{array} \quad \begin{array}{l} \text{First, 2 Farthings divided by} \\ \text{4, quotes .5 d. and then 7.5 d.} \\ \text{divided by 12 quotes .625 s.} \\ \text{Lastly, 7.625 s. divided by 20,} \\ \text{quotes .38125 l.} \end{array}$$

But if any Divisor greater than of 12, be composed of two Digits, divide by those Digits continually, and you have the Quotient required; So in the following Example, to divide by 28; I first divide by 4, and the Quotient thence arising by 7.

Reduce 9 oz. 17 d. wt. 14 gr. to the Decimal of a lb. Troy.

$$\begin{array}{r|l} \text{Instead of 28} & \begin{array}{l} 2 \mid 14 \\ 12 \mid 7 \\ 20 \mid 17.583 \\ 12 \mid 9.87916 \\ \phantom{12} \mid .8232638 \end{array} \end{array}$$

The Answer.

Reduce 3 cwt. 3 qrs. 3 lb. to the Decimal of a Tun.

$$\begin{array}{r|l} \text{Instead of 28} & \begin{array}{l} 4 \mid 3. \\ 7 \mid .75 \\ 4 \mid 3.10714285 \\ 20 \mid 3.7767857142 \\ \phantom{20} \mid 1.88839285714 \end{array} \end{array}$$

The Answer.

Reduce

# Reduction of Denominations 103

Reduce 41 Gallons and 5 Pints to the Decimal of a Hoghead, containing 63 Gallons.

$$\begin{array}{r} 8 \overline{) 5} \\ 63 \overline{) 41.625} \\ 63 \overline{) 41.625} \\ 63 \overline{) 41.625} \end{array}$$

The Answer.

Reduce 8 to 11 a Duodecimal to a Decimal.

$$\begin{array}{r} 12 \overline{) 11} \\ 12 \overline{) 10.916} \\ 12 \overline{) 8.90972} \\ .742476852 \end{array}$$

The Answer.

Reduce 42 11 53 2 Sarges to a Decimal.

$$\begin{array}{r} 60 \overline{) 53} \\ 60 \overline{) 11.883} \\ 60 \overline{) 42.19805} \\ .703300083 \end{array}$$

The Answer.

But the Decimal of any Number of Shillings, Pence and Farthings, as 6 s. 9 d. may be written down in one Line without any Burthen to the Memory : For if in the place of Primes be written half the Number of Shillings (.3), and the Pence reduced to Farthings (38) written after them if less than 6 d. or written after them increased by one, when as much as, or more than 6 d. then

then this (.339) shall be the Decimal true to three Places; And if (7) half the Number of Farthings rejecting Sixpences, be divided by 12, the Quotient (.583) written after the three places (.339) shall complete the Decimal (.339583) of 6 s. 9 d.  $\frac{1}{4}$ .

But observe that if the Number of Shillings be odd, then the second place of Decimals shall be increased by 5; and so the Decimal of 7 s. 9 d.  $\frac{1}{4}$  is .389583.

And the like of any other Sum, as 17 l. 10 d.  $\frac{1}{4}$ ; for the half of 17 is 8.5 and the Number of Farthings 41 greater than 64, and therefore the 3 first Places are .892; and the Farthings rejecting Sixpences are 17, whose half 8.5 divided by 12 quotes 7083, and this annexed to .892 gives the Decimal sought .8927083.

There are also particular Methods for expressing Weights, Measures, &c. Decimally, without waste Figures or Burthen to the Memory; which for Brevity's sake I omit.

Only observe that .00274 (because very near the Decimal Part of a Year, answering to one Day) multiplied by the Number denoting any Days, gives the Decimal Part of a Year, answering to those Days very near. And this because of its use in Interest and Annuities, I would not omit.

## S E C T. III

*To reduce a Decimal to the least Vulgar possible.*

### THE RULE.

**M**AKE the Decimal the Numerator of a Fraction, whose Denominator shall be an Unit with as many Cyphers annexed as there are places





# 106 Reduction of Denominators

9990000000

1741734375

1741734375

2272031257

3006250000

16765625

13298875

3468750

2890625

578125

578125) 9990000000 (1728

4208750

1618750

4625000

1636093

578125) 741734375 (1284

1636093

4798437

1734375

Answer 134

SECT.

and weights

Refer

## S E C T. IV.

To value any DECIMAL in a lower Denomination.

### THE RULE.

**M**ultiply the given Decimal by the Number of the lower Denomination contained in one of the greater, and the Product shall be the Answer.

Reduce .317 l. to Shillings.

$$\begin{array}{r} .317 \\ \times 20 \\ \hline 6.340 \end{array} \text{ Shillings.}$$

And so the Answer is 6.34 s. But if it had been required to value .317 l. in Shillings, Pence and Farthings; First value is in Shillings, and then value the Decimal Parts of Shillings in Pence, and if there be any Parts of Pence value them in Farthings.

Value .317 l. in Shillings, Pence and Farthings.

$$\begin{array}{r} .317 \\ \times 20 \\ \hline 6.340 \\ \times 12 \\ \hline 4.008 \\ \times 4 \\ \hline \end{array}$$

.32 Ans. 6s. 4d. 0.32f.

And in the same manner value Weights and Measures.



But the Decimal Part of a Pound Sterling may be valued shorter, thus. Subtract all the Primes, and a half Prime if there be one; then multiply the Remainder by 4, placing the Product under the Remainder but two places towards the Right hand; which taken from the aforesaid Remainder, leaves a Number, from which cut off to the Right hand, as many places as there were in the first Remainder, by a separating Point; and the double of the Primes and half Primes give the Shillings, and the Figures to the Left-hand of the separating Point, give the Farthings, which reduce to Pence and Farthings, and those to the Right-hand give the Decimal of a Farthing.

Value .3647 l. in Shillings, Pence and Farthings.

$$\begin{array}{r}
 .3647 \\
 \times 4 \\
 \hline
 14588
 \end{array}$$

That is 147 by 4.

Answer 7s. 2d. 2.125f

But the Primes and the half Prime when there is any may be conceived to be subtracted, and the Product made of the Remainder by 4 may be subtracted, without setting down as in Division. And then the true Value of any Decimal Parts of a Pound Sterling are had without any waste Figures, or Burthen to the Memory.

Value .3741 l. in Shillings.

Answer 7s. 5d. 3.136f.

But if the Shillings be valued, as before, and the remaining Figures in the second and third places, abating one in 25, be called Farthings; the Value of the Decimal shall be had so near, that the Error shall never come to a Farthing.



# CHAP. XIV.

## Extraction of Roots of Decimals.



### The RULE.



SET a Point over the Place of Units, and also over every Place upwards and downwards as taught in Integers; and then extract as in Integers.

What is the Square Root of 272.25

$$\begin{array}{r}
 272.25 \\
 \sqrt{\phantom{000000}} \\
 86425 \\
 \hline
 812
 \end{array}$$

Answer 164

For the Places of Integers in the Root shall be as many as there are Points over the Integers.

If the Number given have not an exact Root, by bringing down a Period of Cyphers every time, you may proceed to a sufficient Exactness.

If at any time there are Figures to be brought down, but they are not a Period (that is 2 in the Square, 3 in the Cube, &c.) supply the Defect with Cyphers.

Ex-

# Extraction of Roots of Decimals. III

Extract the Square Root of 2042792, &c.

$$\begin{array}{r}
 2042792 \\
 \underline{885} \quad 21355 \\
 161860 \\
 \underline{1883550} \\
 4107900 \\
 \underline{422368} \\
 \text{Answer } 2042792, \&c.
 \end{array}$$

Extract the Cube Root of 10003086964798.

$$\begin{array}{r}
 10003086964798 \\
 \underline{187} \quad 108 \quad 1309 \\
 22109 \\
 \underline{7933479} \\
 2015 \quad 13467 \quad 18075 \\
 \underline{1356775} \\
 1146604809 \\
 20258 \quad 1866875 \quad 162064 \\
 \underline{136849564} \\
 54808288000 \\
 202744 \quad 127011692 \quad 810976 \\
 \underline{1370980176} \\
 367266 \\
 \text{Answer } 10003086964798, \&c.
 \end{array}$$

CHAP.



## CHAP. XV.

### *Approximations to FRACTIONS or Proportions in smaller Terms.*



**L**ET the Fraction  $\frac{2684769}{8376571}$  (or the Proportion of 2684769 to 8376571) be assigned, to find one equal to it, if possible, or at least the next greater, or the next lesser, which may be expressed in Numbers not greater than 999; that is in Numbers not exceeding 3 Places.

If the Fraction sought (whose Terms are not to be greater than [999] a given Number) be the next greater than a Fraction proposed, divide the proposed Fraction's Denominator [8376571] by its Numerator [2684769]; (if the next lesser divide the Numerator by the Denominator) continuing the Quotient [3.12003416] in Decimal Parts to such an Accuracy as shall be sufficient; which



# *Approximations to Fractions, &c.* 113

which Quotient  $[3.12003416]$  for the next greater, is to be the Denominator answering to the Numerator 1: But for the next lesser, it is to be the Numerator answering to the Denominator 1, completing the Fraction as near as shall be necessary to that proposed, which Fraction  $[7.10001472]$  I call the first Fraction compleat; And the same wanting the Appendage of Decimal Parts, I call,  $[+]$  the first Fraction curtailed.

Then by this Appendage  $[12003416]$  of the first Fraction, Divide 1 Integer, and by  $[8]$  the Integer Number which is next less than the full Quotient  $[3.9]$ , Multiply both Terms of the first Fraction compleat; and the Products  $[8 \& 24.96027328]$  of such Multiplication, I call the continual Increments of those Terms respectively. And  $[.03972672]$  so much as the Appendage of Decimal Parts in such continual Increment wants of 1 Integer, I call the Complement of the Appendage of the continual Increment.

Then both to the Numerator  $[7]$  and the Denominator  $[3.12003416]$  of the first Fraction, add (respectively) its continual Increment, which make  $[9 \& 28.08030744]$  the Terms of the second Fraction, and these again (respectively) increased by the same continual Increments, make the Terms of the third Fraction  $[17 \& 37.04058072]$ ; and so onwards, till the Fraction  $[71.00085406]$  so arising, hath an Appendage, less than the Complement of the Appendage of the continual Increment.

And then this Fraction I call the last of the first Order; which also is to be the first of the second Order.

By the Appendage of this Fraction (the first of the second Order), divide the Complement of the Appendage of the continual Increment of the

# 114 *Approximations to Fractions, &c.*

foregoing Order, and by [46] the Integer Number next less than [46.] the full Quotient of such Division, Multiply each Term of the first Fraction of this Order; and to [1150 & 3588.03928400] the Products (respectively) add the continual Increments of the foregoing Order [8 & 24.96927328]; the Results of which [1158 & 3612.99955728], I call the Increments of the present Order. And [.00044272] so much as the Appendage of such continual Increment wants of 1 Integer, I call (as before) the Complement thereof.

Then to [25 & 78.00085490] the Terms of the first Fraction of this (second) Order, add the respective continual Increments of this same Order, and so continually; for the second, third, and subsequent Fractions of this Order, so long as there is an Appendage as great as the Complement of the Appendage of the continual Increment of the same Order; and when the Appendage is less, such Fraction is last of the present Order, and first of the following.

[In this Example the Terms of the second Fraction of this Order, are 1183 & 3691.00011128; Therefore this Order hath no third Fraction, for the Appendage is less than the Complement of the Appendage of the continual Increment. We therefore should proceed to the third and subsequent Orders, but that the Terms of the Fraction last found  $\frac{1183}{3691}$  are greater than [999] the proposed Limit; and because after  $\frac{1183}{3691}$  there is none (before this) nearer to the just Value, it is evident that  $\frac{1183}{3691}$  is the Fraction sought, as being nearest (to the true Value) of any (greater than it) in Terms not greater than 999, and also in the smallest Terms.]

25 2114 1000 111

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But

## *Approximations to Fractions, &c. 115*

But when the Limits will permit it, we may proceed, making up (as is already shewn) the continual Increments of each Order, of such Multiples of the Terms of the first Fraction of the same Order, adding thereunto the continual Increments of the Order next foregoing; and continuing each Order so long as there is a sufficient Appendage, (not less than the Complement of the Appendage of the continual Increment of the same Order;) And when the Appendage becomes less than such, this Appendage dividing that Complement, shews by the Quotient (that is, by the greatest Integer Number less than it) how many times the Terms of that Fraction (where this happens) are to be taken, together with the continual Increments next foregoing, to make the continual Increments of the succeeding Order.

And the Fractions thus arising (which I call the first, second, third, &c. of the first, second, third, &c. Order) without their Appendages of Decimal Parts, (which therefore I call Fractions curtailed) do continually more and more approach to the Value of the Fraction proposed; and are each of them the nearest greatest, or the nearest lesser (as is said) of any not consisting of greater Terms: Nor is there (in Integers) any other such intermediate Approaches. Of all which, if we make Choice of such as have the greatest Terms, not exceeding the Limit proposed, we have what was required.

And what is said of the Numerator and Denominator of Fractions (whether proper or improper) is easily applicable to the Antecedent and consequent Terms of a Proportion.

But here it is fit to be noted, that in seeking the first Fractions (by Division it is convenient to continue the Quotient to at least twice as many Places (or somewhat more) of Decimal Parts, as

## 116 *Approximations to Fractions, &c.*

are the Places of that Number proposed as the Limit, greater than which the Terms of the Fraction sought are not to be.

Among the Multitude of Examples of the like Process, if it be required to find Integers that will express the next least, or next greater Proportion than that of 1 to 3.141592653589793+ (which is that of the Diameter of a Circle to its Circumference) under a given Limit; We may not only speedily attain the same Numbers of *Archimedes* 7 & 22, and also those of *Metius* 113 & 355, (the Invention of which hath raised Wonder in Ingenious Men, and rendered the Memory of the Authors Immortal) but also discover others much nearer in Integers, though in higher Numbers. And he that is unwilling to take the Pains to do it himself, may find it ready done to his Hands; and also this Subject largely enquired into, by the Reverend Dr. Wallis, in the 10th and 11th Chapters of his *History of Algebra*. From whence I extracted this Chapter.

THESE THINGS BEING NOW PRESENTED TO THE  
VIEW OF THE READER, I SHALL NOW  
PROCEED TO THE EXAMINATION OF THE  
METHODS OF APPROXIMATION, AND  
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CHAP.

CHAP. XVI.

Of DUODECIMALS.



**S**INCE Duodecimals are the Foundations of many of our *English Measures*, to say something of the Management of them may be very useful, especially to the Builder. But because Addition and Subtraction, are performed in all respects like Addition and Substraction of Pence, I shall omit their Rules and Operations. And because Multiplication is the very necessary Part, but Division only when the Divisor is an Integer, and Extractions scarce at all, when we measure according to any of the various Customs used; Besides, if such Operations were required, it is better to reduce them to Decimals; I shall therefore treat of Multiplication fully, of Division sparingly, and omit Extractions and Reductions.

To multiply Integers, Primes, Seconds,  
 &c. by Integers, Primes, Seconds, &c.

### The RULE.

**S**ET the Multiplier so under the Multipli-  
 cand, that the Integers of the Multiplier  
 stand under the lowest Place of the Multiplicand,  
 and the other part of the Multiplier in order, to  
 the Right-hand; then multiply the Multiplicand  
 by each Term of the Multiplier, beginning at  
 the Right-hand, setting the Right-hand place  
 of each Line under the Multiplying Figure,  
 and carrying one for every 12 to the next  
 place.

Ex. 1. Multiply 5 03 03 by 3 05 07.

$$\begin{array}{r}
 5\ 03\ 03 \\
 \underline{3\ 05\ 07} \\
 15\ 09\ 09 \\
 15\ 09\ 09 \\
 \hline
 15\ 09\ 09
 \end{array}$$

The Answer.

Ex. 2. Multiply 6789 06 04 by 24 03 08.

$$\begin{array}{r}
 6789\ 06\ 04 \\
 \underline{24\ 03\ 08} \\
 165023\ 02\ 11\ 02\ 08 \\
 1697\ 04\ 07\ 00 \\
 377\ 04\ 04\ 02\ 08 \\
 \hline
 165023\ 02\ 11\ 02\ 08
 \end{array}$$

The Answer.

In

# Of Duodecimals.

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In the 2d Example after I had multiplied 65' 04'' by 08'' and stated 02' 10' 08''' for the Product, besides 04'' to be carried, I multiplied 6789 by 08'', which with 04'' carried, produced 54316'', which, reduced according to the common Rules of Reduction, becomes 377 04' 04''; And in multiplying by 03' I proceeded in like manner when I came to the Integers of the Multiplicand; which being duly observed, sufficiently illustrates the Rule.

But besides the foregoing general Method, there are many particular ones adapted to particular Cases, which render the Operations very easy; and the most Remarkable follow.

To multiply any Integers, Primes, Seconds, &c. by 12 Integers; first carry the Duodecimals one place higher, till you come to Integers, and then to the Product of the Integers of the Multiplicand by 12, add the Primes of the Multiplicand.

Ex.  $\begin{array}{r} 417\ 07\ 09\ 11 \\ \times 12 \\ \hline \end{array}$  by 12.

$\begin{array}{r} 5011\ 09\ 11 \\ \hline \end{array}$

To multiply any Integers, Primes, Seconds, &c. by a Multiple of 12 Integers; first Multiply by 12, and then the Product by the Number expressing what Multiple the Multiplier is of 12.

$\begin{array}{r} 417\ 07\ 09\ 11 \\ \times 12 \\ \hline \end{array}$  by 72, or 6 times 12.

$\begin{array}{r} 5011\ 09\ 11 \\ \hline \end{array}$

$\begin{array}{r} 30070\ 11\ 06 \\ \hline \end{array}$

The Answer.

But

But if the Multiplying Integer consists of some Multiple of 12, and some Number over; first multiply by the Multiple, and to the Product add that made by the Multiplicand, multiplied by the Excess of the Multiplier above the Multiple.

$$\begin{array}{r}
 417\ 07\ 09\ 11 \text{ by } 77, \text{ or } 6 \text{ times } 12 \text{ with } 5 \\
 \hline
 5011\ 09\ 11 \quad 12 \\
 30070\ 11\ 08 \quad 72 \\
 2088\ 03\ 01\ 07 \quad 5 \\
 \hline
 32159\ 02\ 07\ 07 \quad 77
 \end{array}
 \left. \begin{array}{l} \\ \\ \\ \end{array} \right\} \text{times the Multiplicand.}$$

To multiply Integers, Primes, Seconds, &c. by any Number of Primes that is an Aliquot Part of 12: Take such a Part of the Multiplicand, as the Multiplier is of 12<sup>th</sup>, and if any thing remain, either in Integers, Primes, &c. esteem it so many such Parts of that Place, but value it in a Number of the next Place. So in the following Example, after the 3<sup>d</sup> Part of 317 is taken, there remains 2, which are Thirds of an Integer, and because  $\frac{1}{3}$  of an Integer is 4', and so  $\frac{2}{3}$  are 8', I carry 8' to 2' the Third Part 7', which makes 10'; and so in any other Place.

$$317\ 07\ 05 \text{ by } 4$$

$$105\ 10\ 05\ 08 \text{ The Answer.}$$

But if the Multiplier be 1, take a twelfth Part of the Integers, and place the Remainder under Primes, and move the Primes, Seconds, &c.



# Of Duodecimals.

121.

Ec. in the Multiplicand one place lower in the Product.

$$\begin{array}{r} 317 \text{ } 07 \text{ } 05 \text{ by } 01 \\ \hline 26 \text{ } 05 \text{ } 07 \text{ } 05 \end{array} \quad \text{The Answer.}$$

To multiply any Number of Integers, Primes, Seconds, Ec. by a Number of Primes that is an Aliquant Part of 12'; first see what aliquot Parts of 12' added together, will make the Multiplier; then multiply the Multiplicand by such Aliquot Parts, and the Sum of the Products shall be the Answer.

$$\begin{array}{r} 317 \text{ } 07 \text{ } 05 \text{ by } 10 \text{ or } 6 \text{ and } 4. \\ \hline 158 \text{ } 09 \text{ } 08 \text{ } 05 \\ 105 \text{ } 10 \text{ } 05 \text{ } 08 \\ \hline 264 \text{ } 08 \text{ } 02 \text{ } 02 \end{array} \quad \text{The Answer.}$$

$$\begin{array}{r} 172 \text{ } 07 \text{ } 06 \text{ by } 11 \text{ or } 4 \text{ \& } 4 \text{ \& } 3. \\ \hline 57 \text{ } 06 \text{ } 05 \\ 57 \text{ } 06 \text{ } 06 \\ 43 \text{ } 01 \text{ } 10 \text{ } 06 \\ \hline 158 \text{ } 02 \text{ } 10 \text{ } 06 \end{array} \quad \text{The Answer.}$$

But in this Case, the Answer may be had, by taking a twelfth Part of the Multiplicand from the Multiplicand.

$$\begin{array}{r} 172 \text{ } 07 \text{ } 06 \text{ by } 11 \\ \hline 14 \text{ } 04 \text{ } 07 \text{ } 06 \\ \hline 158 \text{ } 02 \text{ } 10 \text{ } 06 \end{array} \quad \begin{array}{l} \text{Equal to the } 12^{\text{th}} \text{ Part} \\ \text{of the Multiplicand.} \\ \text{The Answer.} \end{array}$$

R

To

To multiply Integers, Primes, Seconds, &c. by Seconds or Thirds, &c. multiply as for Primes, only let the Product one place lower for Seconds, two for Thirds, &c. But observe that if in such Operations, the Primes are more than 11 they shall be reduced to Integers, as in the Second Example of this Chapter; and the like of any other Duodecimal place.

$$\begin{array}{r}
 767 \text{ } 03 \text{ } 05 \text{ } 07 \text{ } 3 \\
 \times 191 \text{ } 09 \\
 \hline
 15 \text{ } 11 \text{ } 09 \text{ } 10 \text{ } 03
 \end{array}$$

And all these Directions put together, shew us many easie and expedient Methods for multiplying Integers and Duodecimals by Integers and Duodecimals; and are, as I conceive, the most material.

To divide Integers, Primes, Seconds, &c. by an Integer, first divide the Integers; and if any thing remain, reduce it to Primes, to which add the Primes given, and then divide for Primes; and if any thing remain, reduce it to Seconds, and work as before.

$$\begin{array}{r}
 45) 732. \text{ } 04 \text{ } 08 \text{ } (16 \text{ } 03 \text{ } 03 \text{ } 07 \text{ } \frac{2}{3} \text{ } \text{or } \frac{1}{3} \\
 \underline{282} \\
 12 \\
 \underline{148} \\
 13 \\
 \underline{164} \\
 29 \\
 \underline{348} \\
 33
 \end{array}$$

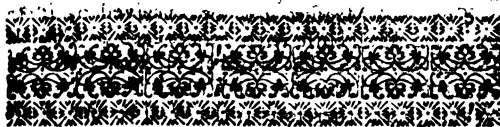
What-

Whatsoever hath been said of Decimals concerning Interminates, whether certain or uncertain, may be applied to Duodecimals or Sexagesimals; if what is there said of 9, be here applied to 11 and 59.

Having entered on the handling of Duodecimals, whose use is in Measuring, it may not be amiss to conclude with an Idea of Measuring, different from what is taught by our Modern Authors, and what may help to correct the false Ideas so common of Multiplication, even in some of our best Authors, and consequently not improper in a Treatise of Numbers.

R 2

C H A R.



THE ART AND MYSTERY OF MEASURING

# CHAP. XVII.

## OF MEASURING.

OF MEASURING

OF MEASURING



VERY Magnitude is measured by some Magnitude of the same kind. A Line by a lineal Foot, Yard, &c. A Superficies by a Square Foot, Yard, &c. A Solid by a Cubick Foot, Yard, &c.

The Lineal Measure is known to all.

The Superficial Measure may be conceived, by imagining a Floor paved with Tiles, each a Square Foot; for then the Number of Tiles is equal to the Number of Square Feet in that Flooring. Now if the Flooring be just one Foot broad, the Number of Tiles (or of Square Feet) will be equal to the Number of Lineal Feet, in the Length of the Floor: But if the Flooring be 2, 3, 4, 5, &c. Feet broad, the Number of Tiles (or of Square Feet) will be twice, thrice, four-times, five-times, &c. so many Tiles (or Square Feet.) So if the Floor were 11 Foot long, and 7 Foot broad, 7 times 11 Tiles (or Square Feet)

Feet) gives 77 the Number of Tiles (or Square Feet) in that Flooring.

The solid Measure may be conceived by imagining a Wall built with Stones each a Cubick Foot; for then the Number of Stones will be equal to the Number of Cubick Feet in that Wall. First therefore if the Wall be one Foot thick, and one Foot high, the Number of Stones (or Cubick Feet) will be equal to the Number of Lineal Feet in the Length of the Wall. Secondly, If the Wall should be of the same Length, and Height one Foot, as before, but the thickness 2, 3, 4, 5, &c. Feet (instead of one Foot); then the Number of Stones (or Cubick Feet) will be accordingly twice, thrice, four times, five-times, &c. as many as before. Lastly, if the Length and thickness be the same as in the last supposition, but the Height (instead of one Foot) be 2, 3, 4, 5, &c. Feet; the Number of Stones (or Cubick Feet) will be accordingly twice, thrice, four-times, five-times, &c. what it was in the foregoing. So if a Wall is 7 Foot long, 3 Foot thick, and 5 Foot high. From what hath been said, a Wall of 7 Foot long, 1 Foot thick, and 1 Foot high, consists of 7 Cubick Feet; but a Wall of 7 Foot long, 3 Foot thick, and one Foot high consists of 3 times 7 Cubick Feet, that is 21 Cubick Feet; lastly, a Wall (of 7 Foot long and 3 Foot thick) as before, but 5 Foot high contains 5 times as many, that is 5 times 21 Cubick Feet, or 105 Cubick Feet.

From all which, its is evident, that in casting up any mensuration, the Multiplier in any of the Multiplications is an abstract Number, as well as in all other Multiplications whatsoever. Which may prevent the false Consequences usually drawn from multiplying Feet by Feet, viz. That of multiplying by a contract Number; as

2 l. 10 s. by 3 l. 10 s. or half a Crown by half a Crown; which is contrary to the Nature of Multiplication, whose Operations are only Compendious Additions, either of the Multiplicand or some part of it, continually to itself, or its part.

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**F I N I S H**

James D. ...

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1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific requirements of the task.

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...and the ...

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57.



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# ERRATA.

**P**AGE 2. Line 20. dele and all Numbers less than 10000, that are not in the following Table are composed.

Pag.	Lin.	For	Read
15	4	$\frac{3187}{1111}$	$\frac{3187}{1111}$
22	3	ibid.	id.
34	18	improper	Compound
48	3	quotes $\frac{3868}{1841}$	quotes $\frac{6723}{1841}$
59	6	11 Definition	17 Definition
59	21	24.21	24.021
67	2	467.2145	476.2145
ib.	20	473	4.73
68	1	1769675	1769.675
69	5	17.92644553	17.88644553
75	9	117880246913	117880246913
75	11	.15773	1.5713
75	12	24.04851	24.04852
78	12	1128322222	112.8322222222
81	22	248	2.48
89	3	12183+	.12183+
ib.		12184—	.12184—
90	28	3 in the Dividend	3 in the Quotient
92	37	.041764	(.41764

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